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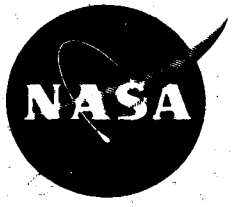
A PRODUCTION CONTROL AND ACCOUNTING SYSTEM

DONALD E. JAMISON

SEPTEMBER 1967



GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

A PRODUCTION CONTROL

AND

ACCOUNTING SYSTEM

Donald E. Jamison
Information Processing Division

September 1967

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

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A PRODUCTION CONTROL AND ACCOUNTING SYSTEM

INTRODUCTION

CURRENT PRODUCTION CONTROL AND ACCOUNTING SYSTEM

The techniques used for production control and accounting in the Data Processing Branch of the Information Processing Division at Goddard Space Flight Center have consisted of constant and progressive adaptations to cope with operational demands. As the work load has increased the requirements for accounting and control within the data processing establishment have correspondingly increased.

The system has evolved from one where records and reports were compiled on the processing of a few hundred magnetic tapes by a few individuals, into one utilizing many people to maintain control and perform accounting work on the processing of thousands of magnetic tapes.

The introduction of data processing equipment into the system of operations has been an integral part of the improvements made to keep pace with the growing processing responsibilities. To complement the operations electronic accounting machines were introduced to produce punched cards which could be used by computers to compile accounting records and summaries of the data processing activities. Magnetic tapes were also introduced into the system for information storage and retrieval. These operations, although mandatory, expanded the manpower requirements and brought about the need for storage and library areas for record keeping.

Inherent in the man-machine relationship are the complex tasks of operations control such as scheduling, accounting and reporting. These tasks, by their very nature, have introduced other work functions that must be efficiently carried out in order to maintain a well coordinated production cycle.

It has been evident for some time that to be able to facilitate the present methods, many of the activities now performed manually, will have to be done by computers. To accomplish this an automated system must be placed into service. Many of the redundant and time consuming aspects of the current system of production control and accounting would be eliminated by automating the various tasks. Manually operated electronic accounting machines could be removed from many steps in the accounting process and operational and storage areas for large quantities of records will no longer be necessary.

The Production Control and Accounting System (Figure 1) proposed in this report, has been developed from an evaluation and study to modernize the present system. The suggested system incorporates data processing equipment available in the Data Processing Branch along with supplementary devices necessary for the system to meet the accounting requirements imposed upon it. It will retain the operational structure of the current organization while offering the tools of automation to centralize and provide more exacting control over the production process.

DATA ACQUISITION NETWORK

The acquisition of satellite telemetry data is conducted by NASA's Space Tracking and Data Acquisition Network. The network is composed of data acquisition and range rate tracking stations. Telemetry data are recorded on analog magnetic tapes at these stations and are sent to the Data Processing Branch at GSFC for information processing.

Two logistics report responsibilities are conducted by the stations to support the orderly flow of magnetic tapes from the field stations to GSFC. The stations communicate with GSFC by teletype and send two different teletyped reports for use by the Data Processing Branch. The first is a cumulative tape report (Figure 2) for every ten tapes recorded at a station. The second teletype message, a Magnetic Tape Shipment List, (Figure 3), contains a list of tapes shipped by a station. Both of these records are later used by the Data Processing Branch to check against the Analog Tape Station Log (Figure 4) which is shipped along with the magnetic tapes to the Data Processing Branch.

DATA PROCESSING BRANCH

The Data Processing Branch receives and processes analog data tapes from the Space Tracking and Data Acquisition Network stations. The operational functions entail several steps. An example of the processing is illustrated in the Data Processing Operation Flow diagram (Figure 5).

The operational requirements are divided into five areas. They are (1) Analog tape evaluation; (2) Analog to Digital Conversion; (3) Telemetry Data Reconstruction; (4) Experiment analysis and (5) Production Control. The fifth area is a by-product of the operational process and involves the control, accounting and record keeping required to maintain a well-ordered data processing organization.

Briefly, the production process is carried out in the following manner. Analog tapes are received from the stations and evaluated for signal quality.

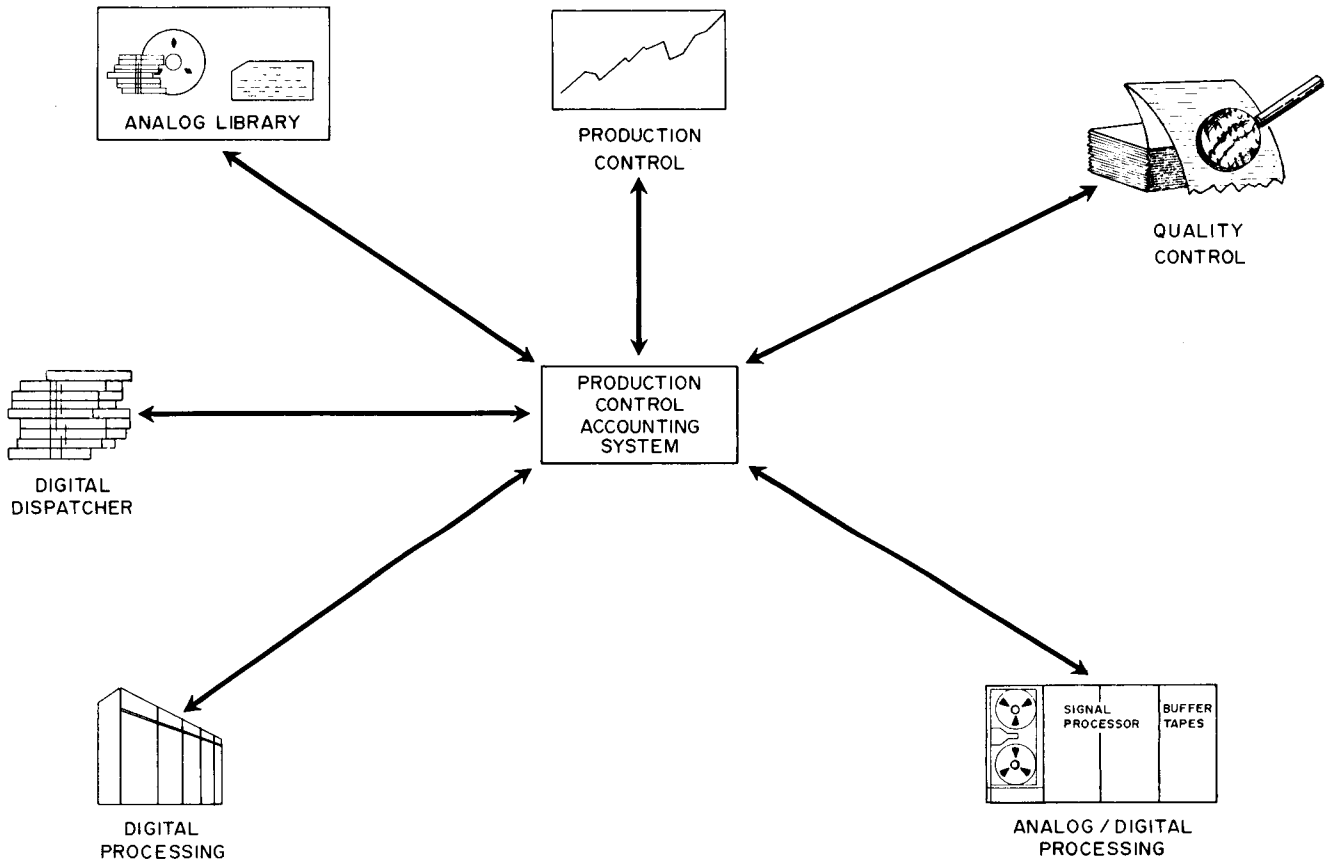

Figure 1. Production Control Accounting System

```
STSØ28

RR GNET GPRK GSTS
 DE GLGE Ø19
15/1854Z
INFO GSTS/CODE 536

REF 1963 38C CUMULATIVE TAPE REPORT.
3758 Ø5Ø3Ø7 Ø25755 Ø31635 3383M144 55555 136.652 19 BCFGJ 2 GSFC
3779 Ø61627 1618ØØ 163655 3383M145 55555 136.652 18 BCFGJ 2 GSFC
3785 Ø7Ø326 Ø31745 Ø33635 3383M145 55555 136.652 19 BCFGJ 2 GSFC
3798 Ø8Ø243 Ø23355 Ø249ØØ 3383M145 55555 136.652 11 BCFGJ 2 GSFC
3812 Ø9Ø346 Ø3373Ø Ø35615 3383M146 55555 136.652 19 BCFGJ 2 GSFC
3832 1Ø1519 151ØØØ 1529Ø5 3383M146 55555 136.652 19 BCFGJ 2 GSFC
3839 11Ø4Ø6 Ø35715 Ø4154Ø 3383M146 55555 136.652 17 BCFGJ 2 GSFC
3845 111436 142645 14453Ø 3383M147 55545 136.652 18 BCFGJ 2 GSFC
3865 13Ø238 Ø23ØØ3 Ø2482Ø 3383M147 55555 136.652 18 BCFGJ 2 GSFC
39ØØ 1517Ø3 16551Ø 17123Ø 3383M147 55555 136.652 17 BCFGJ 2 GSFC
REMARKS:
REV 3758 WWVH 15MC
REV 3798 DATA DEGRADED FROM Ø2454ØZ TO Ø249ØØZ DUE TO ERRATIC
         OPERATION OF TAPE RECORDER.  WWVH  15MC
REV 3832 WWVH 1ØMC
 REV 3839 WWVH  15MC
 REV 3845 WWVH  5MC
 REV 3865 AND 39ØØ WWVH  15MC

 15/19Ø1Z JUL GLGE
```

Figure 2. Teletyped Cumulative Analog Tape Report

This evaluation is performed by sampling. The last tape on each satellite from each station is selected each week for quality checking. The evaluation is used as a performance check for the stations on their recording methods. Data are then converted from an analog to a digital representation on magnetic tapes for subsequent computer processing. Digital data are edited on a computer and appropriate data quality checks are performed. Experiment decommutation, telemetry calibration, and merging is performed. The outputs consist of magnetic tapes, punch cards, printouts and graphed plots. After processing is completed, the analog tapes received from the field stations, and master edit tapes are stored for future use. Decommutated tapes, punch cards, orbit attitude tapes and special purpose tapes are shipped to pertinent experimenters. All the while this processing occurs, bookkeeping data is recorded on the data being generated through the data processing cycle.

```
#
GPR028A
RR GLOG GNET GPRK GSTS GTWL
DE GBUR 059
11/0919Z
TO GSTS/CODE 234
INFO GTWL/CODE 530 STAOPS

REF MAGNETIC TAPE SHIPMENT
1. BOAC BA124 10-11-65 A W B 083-493546

2. BALTIMORE ETA UNKNOWN

3. 7 CARTONS 69 TAPES WEIGHT 148 KILOS

4. SAT NO      TAPE NO
   64031       403Q342-345
   64511       451Q042-045
   64541       454Q112A 1121 1134
   64641       464Q168 169 114Q 115Q
   64741       474Q029
   64762       476Q080
   64861       486Q1918-1928
   65091       5009Q200 201
   65321       5032Q138 115Q 116Q
   65391       5039Q067
   65421       5042Q317-324
   65601       5060Q052
   65891       5089Q001-005
   65811       5081Q164-172

5. LON BA124 0900 AM 11-11-65
   NY TW703 2205 PM 11-11-65
   BALTIMORE FIRAV AM 12-11-65

6. S.D. 345/65

11/0925Z NOV GBUR
```

Figure 3. Magnetic Tape Shipment List

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MAGNETIC TAPE LOG

Date _____

Satellite(s) Name _____

Tape No. _____

Make Recorder _____

Model _____ Serial No. _____

Station Name _____ No. _____

Geodetic Coordinates

Latitude _____

Longitude _____

TRACK	RECORD PLUG-IN: AMPLIFIER	RECORD PLUG-IN: CENTER FREQUENCY	RECORD PLUG-IN: BANDPASS FILTER	LINK (RF) FREQUENCY	TRACK FUNCTION: DETECTED SIGNAL	TRACK FUNCTION: CONVERTED SIGNAL	TRACK FUNCTION: SIGNAL LEVEL	TRACK FUNCTION: TIMING	TRACK FUNCTION: REFERENCE	TRACK FUNCTION: SPEED CONTROL	TRACK FUNCTION: LOCAL	TRACK FUNCTION: SPECIAL	RECORDER INPUTS: CENTER FREQUENCY MODULATION SUBCARRIER BANDWIDTHS, ETC.
1	DPFCN												
2	DPFCN												
3	DPFCN												
4	DPFCN												
5	DPFCN												
6	DPFCN												
7	DPFCN												

TAPE SPEED

I.P.S.

D – Direct
P – Pulse Width
F – FM
C – Control Track
N – Non-return-to-zero

NOT REWOUND

MAILED TO:

Cumulative Msg. DTG. _____

PASS NO.	PREDICT TIME	START TIME	STOP TIME	TAPE NO.	SINPO	LINK (RF) FREQ.	MINS DATA	EQUIP. PARA.	OPER. PARA.	TAPE MAILED

EQUIPMENT PARAMETERS		OPERATIONS PARAMETERS	
1		1	
2		2	
3		3	
4		4	

ADDITIONAL REMARKS

GSFC 22-30 (9/61)

Figure 4. Analog Tape Station Log

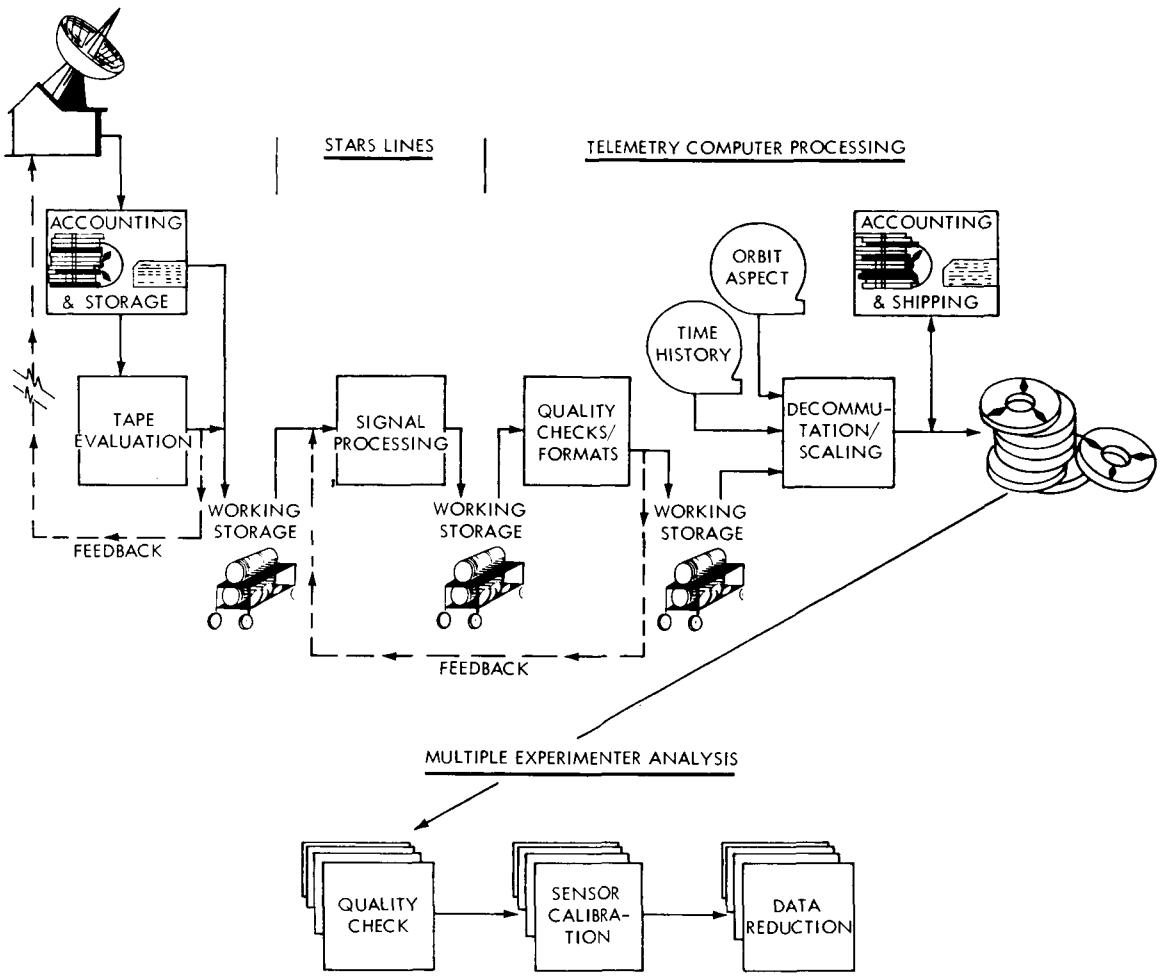

Figure 5. Data Processing Operational Flow

DATA PROCESSING PRODUCTION CONTROL

Production control is necessary to maintain an organized processing operation. In doing so it allows the Data Processing Branch to be informed about the data processing operation at any time. The production control structure of the Data Processing Branch is a system that governs the flow of telemetry data from its entry as raw data until it is passed on as finished processed data (Figure 6).

The production control and accounting tasks are carried out by three offices of the Operations Section of the Data Processing Branch. They are (1) the Analog Data Accounting Office (2) the Production Control Center and (3) the Digital

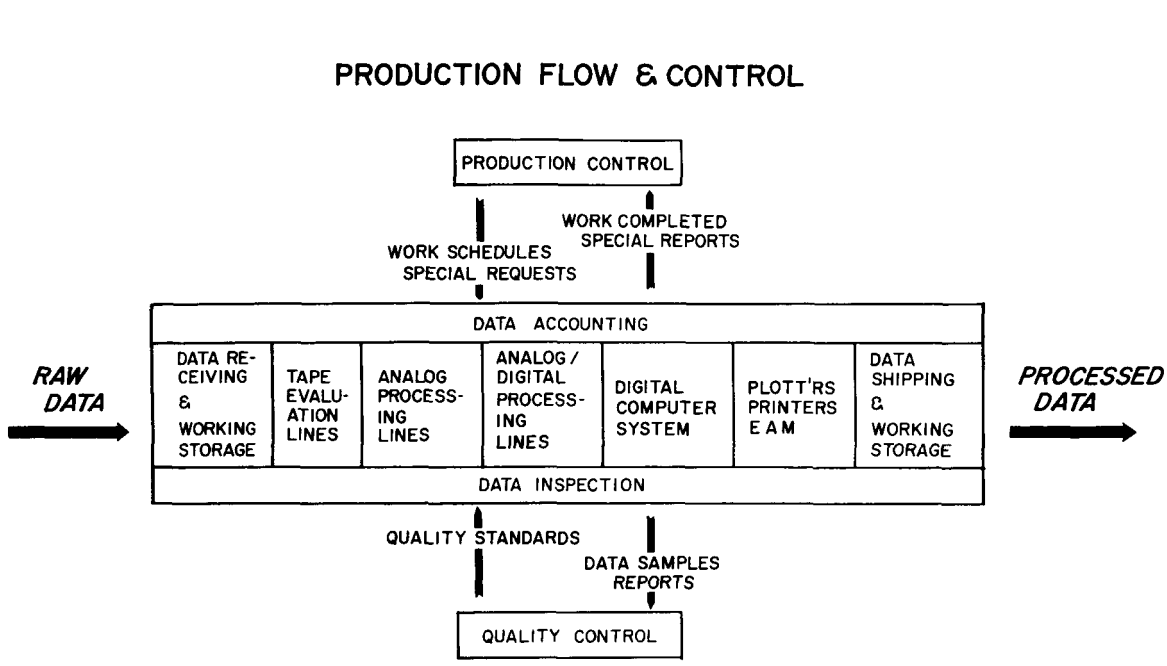

Figure 6. Production Control

Data Accounting Office. The Analog and Digital Data Accounting Office are administratively the same but are functionally distinct and are presented accordingly. Constant record control by these three offices enable the Data Processing Branch to know the status and location of recorded data whenever it is needed.

The different phases of the data processing operation are discussed in relation to the production control office which is responsible for overall control and accountant functions throughout processing.

ANALOG DATA ACCOUNTING OFFICE

The analog data accounting operations are shown in Figure 7. The cumulative tape reports (Figure 2) and magnetic tape shipment reports (Figure 3) are sent by the field stations to the Analog Data Accounting Office by teletype machine. These reports are held by the Analog Data Accounting Office for arrival of analog magnetic tapes from the same stations. Each analog tape received is accompanied by a magnetic tape log (Figure 4) which is then checked against the teletyped reports to see that the correct tapes have been received. The Analog Data Accounting Office must account for the movement of the analog tapes from the time they are received until they are retired to tape archives.

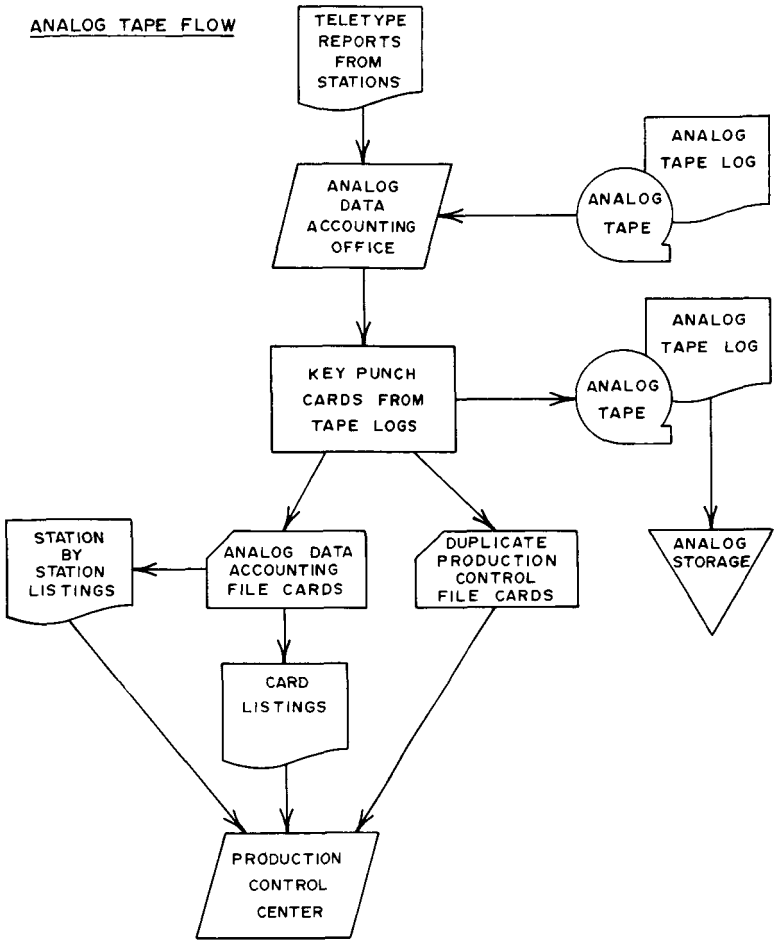

Figure 7. Analog Data Accounting Operations

After the analog tapes have been inspected, an analog tape documentation card is punched. Two cards are punched for each file of data on a tape. One is held for updating by the Analog Data Accounting Office and the other is sent to Production Control for later use (Figure 8). This card contains all the necessary information to determine the processing status of each tape.

Characters are punched over the first 53 columns plus columns 70, 78, 79 and 80 of the card after the analog inspection. The characters represent the initial identification of the tape for processing purposes. It contains the following information:

1. Satellite
2. Station

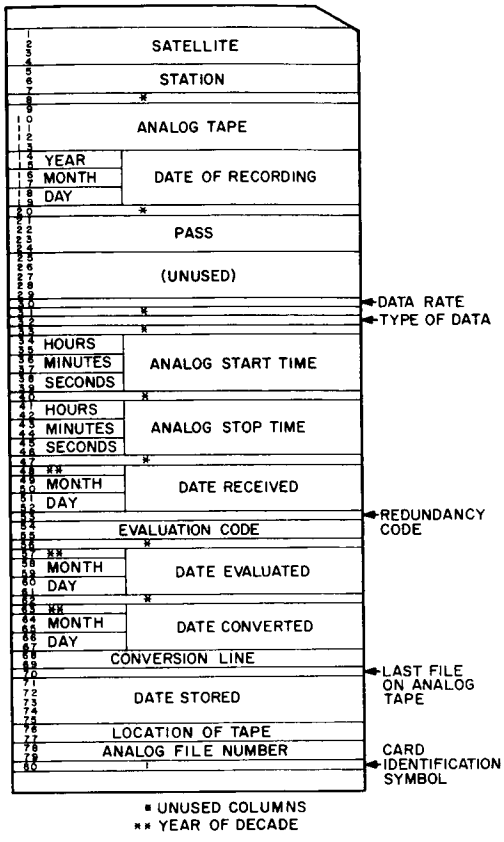

Figure 8. Analog Tape Documentation Card

3. Analog Tape Number
4. Date of Recording
5. Pass Number
6. Analog Start Time
7. Analog Stop Time
8. Date Received
9. Redundancy Code
10. Last File On Analog Tape
11. Analog File Number
12. Card Identification Symbol

The remaining columns of data are punched in later after tape evaluation, analog to digital conversion and final processing has been completed. This information is obtained from the records and logs prepared at the various places processing occurs.

When a tape has been evaluated its associated card is taken from the file and seven more columns are punched. They are columns 54 through 62, which contain; (1) Evaluation Quality Code, (2) Date Evaluated.

When the analog to digital conversion takes place the card is extracted again from the files and columns 63 through 69 are punched with: (1) Date Converted, (2) Conversion Line. Finally, the card is once again pulled to punch information on it after all processing on the analog tape is terminated and the tape is stored. Characters are punched in columns 71 through 79. The punched information tells: (1) Date Stored, (2) Location of Tape.

The magnetic tapes are temporarily stored in the analog tape storage library of the Analog Data Accounting Office until called for. One set of punched cards is held by the Analog Data Accounting Office for updating and listings and for some satellites a duplicate set is forwarded to the Production Control Center who in turn sends it to the computer area when a digital data tape associated with the analog tape reaches there. No further changes are made on the card sent to Production Control.

The punched cards that have been prepared during the day are used to produce a daily listing of analog tapes. This listing is prepared for the Production Control Center's use in scheduling production.

The Analog Data Accounting Office also used the punched cards to produce a weekly station-by-station listing (Figure 9). Permanent retention of the analog accounting data is accomplished by placing the information on a master log kept on magnetic tape. The analog information along with information punched on the cards from later evaluation and digitizing phases, is listed for use by the Production Control Center. The master tape is generated from the analog tape documentation cards, digital tape documentation; i.e., edit, cards (edit) and decommutation cards. (The digital tape (edit) documentation cards and the decommutation cards are explained in sections "Data Edit" and "Decommutation".) This accumulated information is listed in the form of a combined analog and digital tape chronological listing (Figure 10). This report is updated weekly and contains all files of data processed. It is in chronological order of the time a recording has taken place. The list is distributed to the satellite project office, the Production Control Center and the Analog Data Accounting Office.

A16 ANALOG STA/STA LISTING PAGE 005

SAT	STA	TAPE NO	DATE RECORD	PASS NO	INTRNAL CODE			START TIME	STOP TIME	DATE RECD	QTL	DATE EVAL	DATE DIGIT	DATE S/S	CC CT
A16	BPO	0035	640605	1007	64	03	A	225200	235500	40609	A	40611	40618		01
A16	BPO	0036	640606	1008	64	03	A	021400	032100	40609	A	40615	40618		01
A16	BPO	0037	640608	1029	64	03	A	220401	232555	40611	A	40615	40616		01
A16	BPO	0038	640610	1037	64	03	A	001030	011600	40611	A	40616	40616		01
A16	BPO	0039	640610	1043	64	03	A	192033	201710	40611			40616		01
A16	BPO	0039	640610	1044	64	03	A	225500	000920	40611	A	40615	40617		02
A16	BPO	0040	640611	1049	64	03	A	180047	184530	40615			40623		01
A16	BPO	0040	640611	1051	64	03	A	212700	223500	40615			40623		02
A16	BPO	0041	640612	1056	64	03	A	164024	172111	40615			40623		01
A16	BPO	0041	640612	1058	64	03	A	200400	210610	40615			40623		02
A16	BPO	0042	640615	1080	64	03	A	192515	202200	40619			40627		01
A16	BPO	0042	640615	1081	64	03	A	231015	231410	40619			40627		02
A16	BPO	0043	640616	1087	64	03	A	181433	185400	40619			40714		01
A16	BPO	0043	640616	1088	64	03	A	214315	224452	40619	A	40623	40710		02
A16	BPO	0044	640617	1089	64	03	A	005910	015700	40619			40627		01
A16	BPO	0044	640617	1095	64	03	A	201110	211030	40619	A	40622	40627		02
A16	BPO	0045	640618	1102	64	03	A	184700	193840	40623			40626		01
A16	BPO	0045	640618	1103	64	03	A	221540	232445	40623			40626		02
A16	BPO	0046	640619	1104	64	03	A	024903	031330	40623			40626		01
A16	BPO	0047	640619	1109	64	03	A	171130	180610	40625			UD21		01
A16	BPO	0047	640619	1109	64	03	A	172830	180610	40625			UD21		01
A16	BPO	0047	640622	1130	64	03	A	164830	173230	40625			UD21		02
A16	BPO	0048	640622	1132	64	03	A	201755	212050	40625			40715		01
A16	BPO	0048	640623	1139	64	03	A	185233	194840	40625			40715		02
A16	BPO	0049	640623	1140	64	03	A	222100	233400	40625			UD21		01
A16	BPO	0049	640624	1141	64	03	A	015000	024400	40625			UD21		02
A16	BPO	0050	640624	1146	64	03	A	173330	181920	40625			UD21		01
A16	BPO	0050	640624	1147	64	03	A	211200	220640	40625	B	40629	UD21		02
A16	BPO	0051	640625	1152	64	03	A	161000	165030	40629			40706		01
A16	BPO	0051	640625	1154	64	03	A	193740	203330	40629			40706		02
A16	BPO	0052	640626	1159	64	03	A	145100	152500	40629			40706		01
A16	BPO	0052	640626	1161	64	03	A	181500	190750	40629			40706		02
A16	BPO	0053	640626	1162	64	03	A	214750	222215	40706			40716		01
A16	BPO	0053	640629	1183	64	03	A	173600	182630	40706			40708		02
A16	BPO	0054	640629	1184	64	03	A	210500	221335	40706			40708		01
A16	BPO	0054	640630	1190	64	03	A	161755	165710	40706			40716		02
A16	BPO	0055	640630	1191	64	03	A	194100	204530	40706			40708		01
A16	BPO	0055	640701	1198	64	03	A	182110	191710	40706	A	40707	40716		02
A16	BPO	0056	640701	1199	64	03	A	214930	225830	40706			40716		01
A16	BPO	0056	640702	1205	64	03	A	170630	175040	40706			40708		02
A16	BPO	0057	640702	1206	64	03	A	202600	213340	40706			40708		01
A16	BPO	0057	640703	1212	64	03	A	153800	161820	40706			40716		02
A16	BPO	0058	640703	1213	64	03	A	190440	192820	40709			40710		01
A16	BPO	0058	640706	1234	64	03	A	150210	153800	40709			40710		02
A16	BPO	0058	640706	1235	64	03	A	182600	192500	40709			40710		03
A16	BPO	0059	640707	1242	64	03	A	170702	175510	40709			40710		01
A16	BPO	0059	640707	1243	64	03	A	203005	214135	40709			40710		02
A16	BPO	0060	640708	1249	64	03	A	154320	162951	40709			40710		01
A16	BPO	0060	640708	1250	64	03	A	191000	201300	40709			40710		02
A16	BPO	0061	640709	1257	64	03	A	174900	184400	40713			40717		01
A16	BPO	0061	640710	1265	64	03	A	195430	210100	40713	A	40715	40717		02
A16	BPO	0062	640712	1279	64	03	A	211345	215626	40713	B	40714			01
A16	BPO	0063	640713	1286	64	03	A	154858	163554	40716			DELET		01
A16	BPO	0063	640713	1287	64	03	A	191641	202300	40716			DELET		02
A16	BPO	0064	640714	1293	64	03	A	142732	150807	40716			40720		01
A16	BPO	0064	640715	1299	64	03	A	130609	134300	40716	A	40720	40720		02

Figure 9. Analog Tape Station-by-Station Listing

A16 SATELLITE PROCESSING PAGE 035

STA	TAPE NO	FILE NO	DATE RECORD	PASS NO		START TIME	STOP TIME	BUF NO	L	EDIT TAPE	EDIT FILE	RECVD DATE	DIGIT DATE	EDIT DATE	DECOM DATE	SHIP DATE	COMMENTS	
WNK	0106	01	640728	1394	D	061128	063208	317	C	75	2	40812	40817	40818		40820		X
OOM	0104	02	640728	1394	D	071203	073007	315	C	75	3	40804	40814	40818		40820		X
BPO	0074	02	640728	1397	D	161004	165103	294	C	68	16	40730	40731	40805		40807		
SNT	0117	01	640729	1400	A	033400	033510					40810	UD20					
WNK	0106	02	640729	1401	A	045230	045615					40812	UD20					X
OOM	0105	01	640729	1401	A	055545	055700					40805						
WNK	0106	03	640729	1402	D	082823	085001	317		75	4	40812	40817	40818		40820		X
OOM	0105	02	640729	1402	A	090830	100545					40805						
BPO	0075	01	640729	1404	D	150558	152507	297	C	69	15	40803	40803	40806				
BPO	0075	02	640729	1405	A	181002	191709		C			40803	40805					
JOB	0081	03	640730	1407	A	032930	033130					40810	UD24					X
OOM	0106	01	640730	1408	D	044804	054359	303	C	71	16	40805	40807	40808		40811		
SNT	0117	04	640730	1408	D	054654	064337	311	C	74	10	40810	40811	40813				X
WNK	0106	05	640730	1409	A	065215	072553		C			40812	40817					X
OOM	0107	01	640730	1409	D	074748	092517	304	C	71	17	40805	40807	40808		40811		
BPO	0076	01	640730	1411	D	132507	135806	297	C	69	16	40803	40803	40806		40810		
BPO	0076	02	640730	1412	D	165304	174106	297	C	69	17	40803	40803	40806		40810		
LIM	0015	02	640731	1414	A	005830	014300		C			40818	40820					X
JOB	0081	04	640731	1414	D	014301	021506	309	C	73	5	40810	40811	40811		40818		X
SNT	0118	01	640731	1415	A	042400	042600					40810	UD20					
WNK	0106	06	640731	1416	A	053400	054130					40812	UD21					X
WNK	0106	07	640731	1416	A	054930	060300					40818	UD21					X
OOM	0108	01	640731	1416	D	062725	070007	315	C	75	5	40812	40814	40818		40820		X
BPO	0077	01	640731	1418	D	121503	123306	297	C	69	18	40803	40803	40806		40810		
BPO	0077	02	640731	1419	D	154504	161306	297	C	69	19	40803	40803	40806		40810		
BPO	0077	03	640731	1420	D	191905	195906	309	C	73	20	40803	40811	40811				
OOM	0108	02	640801	1423	D	060004	063259	315	C	75	6	40812	40814	40818		00820		X
LIM	0016	01	640801	1423	A	063930	073000					40818						X
WNK	0107	01	640801	1424	D	073601	081011	320	C	75	7	40812	40818	40818		40820		X
OOM	0109	01	640801	1424	D	083203	100959	316	C	75	8	40812	40814	40818		40820		X
QUI	0011	01	640801	1424	A	102613	105800					40818						X
JOB	0082	01	640801	1425	D	113419	120007	312	C	74	11	40810	40811	40813		40818		X
BPO	0078	01	640801	1427	D	175952	183326	306	C	72	4	40806	40807	40810		40813		
JOB	0082	02	640801	1427	A	183300	200010		C			40810	40818					X
SNT	0118	02	640801	1428	D	212700	225417	311	C	74	12	40810	40811	40813		40818		X
SNT	0119	01	640802	1430	D	060014	060516	311	C	74	13	40810	40811	40813		40818		X
WNK	0107	02	640802	1431	D	061459	064621	320	C	75	9	40812	40818	40818		40820		X
OOM	0110	01	640802	1431	D	070851	084559	316	C	75	10	40812	40817	40818		40820		X
QUI	0011	02	640802	1431	A	085900	093800					40818						X
WNK	0107	03	640802	1432	D	094416	102038	320	C	75	11	40812	40818	40818		40820		X
OOM	0111	01	640802	1432	D	104455	121637	317	C	75	12	40812	40817	40818		40820		X
JOB	0083	01	640802	1434	D	180005	184332	313	C	74	14	40810	40811	40813		40818		X
OOM	0111	02	640802	1434	D	184320	191206	317	C	75	13	40812	40817	40818		40820		X
SNT	0119	02	640802	1435	D	200604	213657	312	C	74	15	40810	40811	40813		40818		X
JOB	0083	02	640802	1435	D	213657	221007	313	C	74	16	40810	40811	40813		40818		X
JOB	0083	02	640802	1435	A	213740	221010		C			40810	40812					
MOJ	0023	01	640802	1436	A	230000	230815					40813	UD20					X
OOM	0112	01	640803	1438	D	060005	072000	319	C	75	14	40813	40818	40818		40820		X
SNT	0120	01	640803	1438	D	072028	080005	312	C	74	17	40810	40811	40813		40818		X
WNK	0108	01	640803	1439	A	082930	084210		C			40819	40820					X
OOM	0113	01	640803	1439	D	092505	105530	320	C	75	15	40813	40818	40818		40820		X
WNK	0108	02	640803	1440	A	115930	121300		C			40819	40820					X
JOB	0084	01	640803	1440	A	121030	132510					40818						X
BPO	0078	02	640803	1441	A	144720	153610		C			40806	40813					X
BPO	0079	01	640803	1442	D	181904	191406	314	C	75	16	40806	40813	40818		40820		X

Figure 10. Combined Analog and Digital Tape Chronological Listing

When processing has been completed on analog tapes, and all relevant information has been forwarded to the experimenters, the analog tapes are sent to magnetic tape archives where they are stored.

PRODUCTION CONTROL CENTER

The Production Control Center controls coordinates and schedules workloads for the processing lines. Its responsibilities are: (1) to schedule tapes for processing and storage and (2) to maintain records on the tapes.

The Production Control Center assumes control of tape processing after they are notified that a tape record has been prepared. The Center receives an advanced telemetry tracking report from the Network Engineering Division and a copy of the daily analog tape listing from the Analog Data Accounting Office. The two records are used to prepare a production chart for control purposes (Figure 11). The chart is a record that contains scheduling and status information and must be filled out before processing of the tapes is started. A line of the chart provides information on an analog tape. Analog to Digital Operations under direction of the Production Control Center are illustrated in the flow diagram of Figure 12. The Production Control Center determines which tapes are to be evaluated or processed, for analog to digital, or analog to analog conversions. To initiate processing, the Center issues an Analog Tape Library Request Form (Figure 13). This is a triplicate form. One copy is held by the Production Control Center and the carbon copies accompany the tape as it is processed.

Magnetic Tape Evaluation

Analog tapes received from data acquisition stations are evaluated for recording quality. The Production Control Center selects a sample of incoming tapes for evaluation. An Analog Tape Library Request Form which is a receipt to follow tape movement, is issued to the Analog Data Accounting Library to obtain the tapes. Data inspectors in the Evaluation Group compare the analog signals to standards and record the data on Tape Evaluation Logs (Figure 14). A check is made on recording track assignments, frequency, amplitude and signal modulation. The data is evaluated as good, questionable, and unusable. The overall tape quality is evaluated as processable, limited, questionable or useless. Further analysis is made when the performance logs are summarized into two weekly reports that are manually prepared by Evaluation: the station telemetry report, and the summary of magnetic tapes received and evaluated. The Operations Branch utilizes these reports as a check on the recording techniques of station operators and on the efficiency of station equipment.

PRODUCTION CHART FOR SATELLITE_____ DIGITIZING LINE(S)_____

DATE ORD.	STA.	TAPE NO.	DATE REC.	DATE REC'D	ANALOG		DIGITAL		DATE EVAL +/OR STRIP CHT	DATE DIGITIZED	BUFFER TAPE & FILE NO.	DATE EDITED	EDIT & FILE NO.	PLOTTER ACTION	QUALITY CONTROL ACTION	DATE REORDER	DECOM RUN NO.	DATE DECOMMED	DATE DE-COM SENT TO EXP.	REMARKS
					START	STOP	START	STOP												

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Figure 11. Production Control Chart

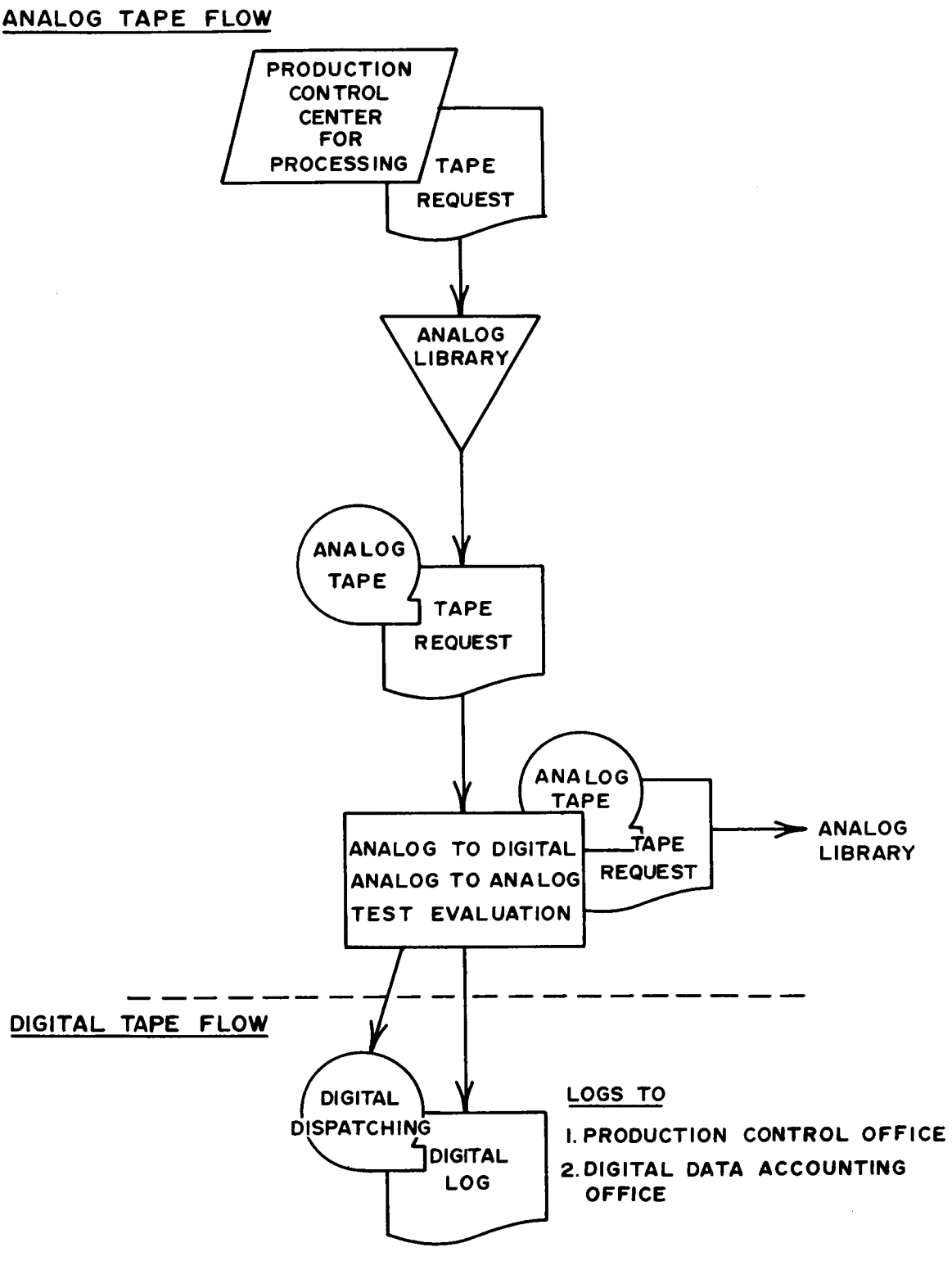


Figure 12. Analog to Digital Operation

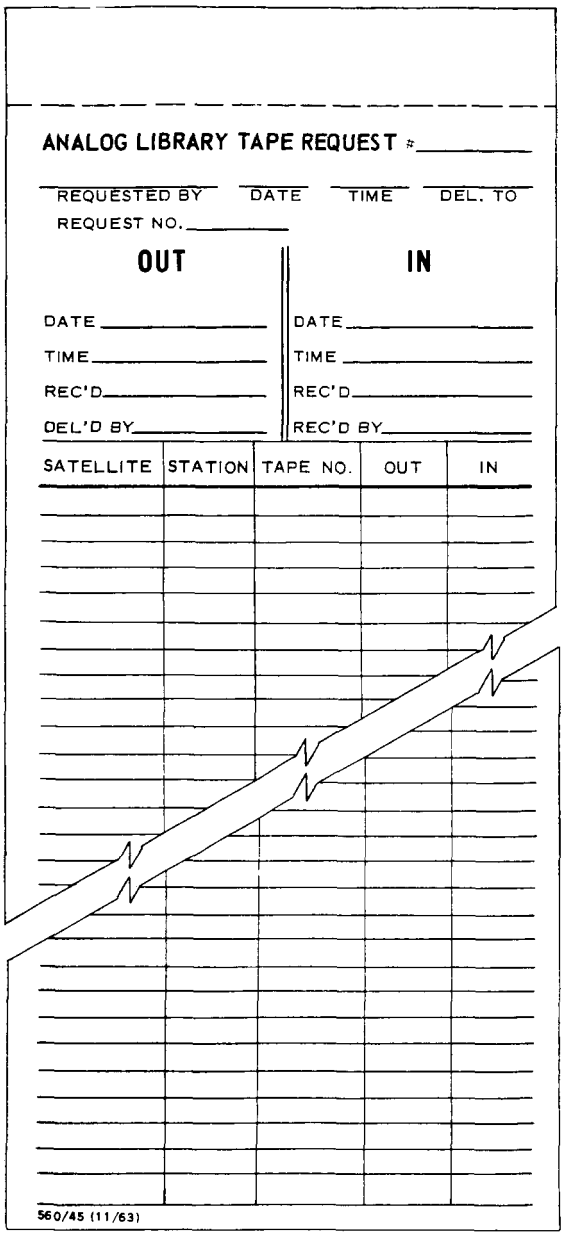
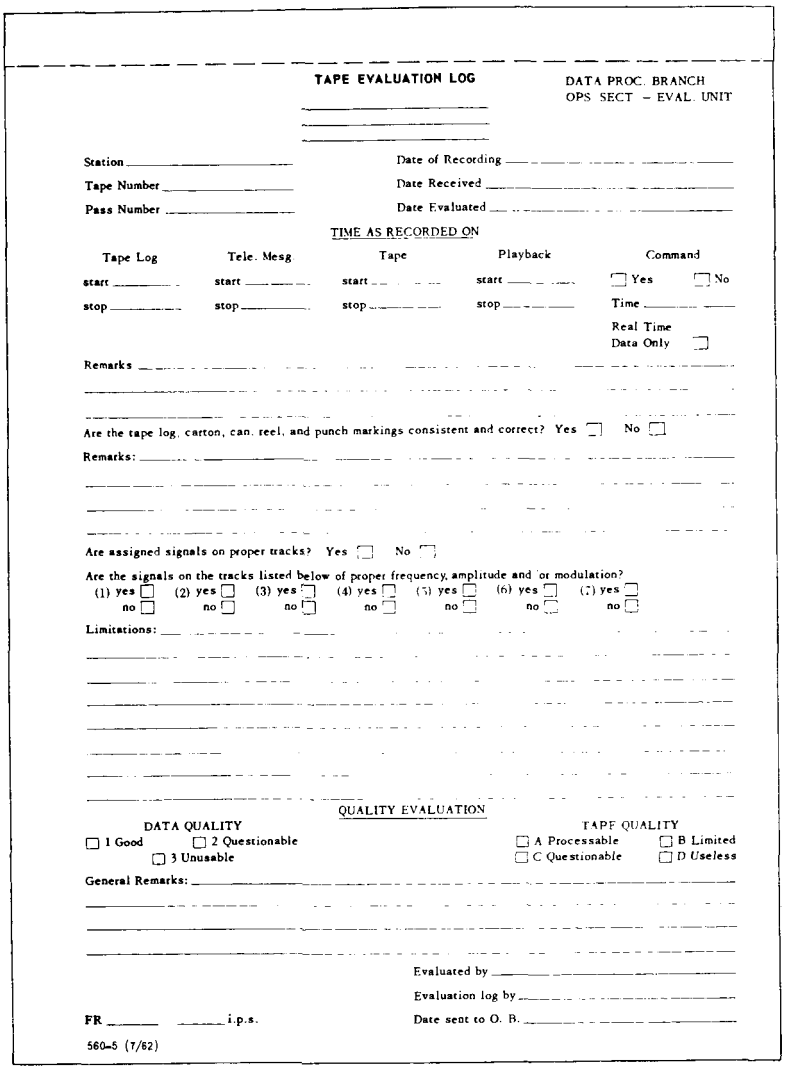


Figure 13. Analog Tape Library Request Form



TAPE EVALUATION LOG

DATA PROC. BRANCH
OPS SECT – EVAL. UNIT

Station _____ Date of Recording _____

Tape Number _____ Date Received _____

Pass Number _____ Date Evaluated _____

TIME AS RECORDED ON

Tape Log	Tele. Mesg	Tape	Playback	Command
start _____	start _____	start _____	start _____	☐ Yes ☐ No
stop _____	stop _____	stop _____	stop _____	Time _____
				Real Time Data Only ☐

Remarks _____

Are the tape log, carton, can, reel, and punch markings consistent and correct? Yes ☐ No ☐

Remarks: _____

Are assigned signals on proper tracks? Yes ☐ No ☐

Are the signals on the tracks listed below of proper frequency, amplitude and/or modulation?

(1)	(2)	(3)	(4)	(5)	(6)	(7)
yes ☐ no ☐	yes ☐ no ☐	yes ☐ no ☐	yes ☐ no ☐	yes ☐ no ☐	yes ☐ no ☐	yes ☐ no ☐

Limitations: _____

QUALITY EVALUATION

DATA QUALITY
☐ 1 Good ☐ 2 Questionable ☐ 3 Unusable

TAPE QUALITY
☐ A Processable ☐ B Limited ☐ C Questionable ☐ D Useless

General Remarks: _____

Evaluated by _____

Evaluation log by _____

FR _____ _____ i.p.s. Date sent to O. B. _____

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Figure 14. Tape Evaluation Log

Analog to Digital Conversion

When enough analog tapes have accumulated so data can be put together for a continuous time period, the Production Control Center sends an analog library tape request and the tape is transported to the analog to digital conversion lines for processing. The outputs of the conversion lines are in the form of digital magnetic tapes whose formats are computer compatible. Each file consists of data collected during one pass of a satellite over a station. The digital tapes and punched cards, made from tapes where both data and commands are recorded, are sent to the Digital Data Dispatching Office for temporary storage until they are used for computer processing.

When a digital buffer tape is produced, an analog-to-digital processing log is filled out by the conversion line operator (Figure 15). This form is a record of information about the condition of the recorded data. An analog-to-digital summary form (Figure 16) is also filled out at this time. Copies of the two forms are distributed to the Production Control Center, a Quality Control Group, and the Contractor Operations Office. Upon approval of Production Control, the keypunch section of the Analog Accounting Office updates the analog documentation card.

The Production Control Center schedules data edit runs on the computer and requests the Digital Data Dispatching Office to forward the digital tapes and accompanying material to the computer room at specified times.

When a production run is made up by the Production Control, a production schedule (Figure 17) sheet is made up listing all the digital tapes to be edited by the computers.

DIGITAL DATA ACCOUNTING

The Digital Data Accounting Office performs the record keeping of all activities taking place after analog-to-digital processing ends and the edit stage begins. The Digital Data Dispatching Office releases the tapes that are processed on computers when they receive a computer production schedule for Production Control. The digital data tapes that are used for edit runs, analog cards and computer scheduling forms are released from the Dispatching Office and are returned to it after processing. Weekly reports are prepared by Digital Data Accounting to provide quantitative information on the number of analog files processed, the number of tapes to be processed and the number of tapes shipped. The operational aspects of the Digital Data Accounting are shown in Figure 18 and Figure 19.

DARSEL GRAPHIC ART SERVICES, INC.

ANALOG TO DIGITAL PROCESSING LOG

SATELLITE _____

Station: **Tape #** **Date** / /

A/D Line # **Buffer Tape #** **File #**

Date Processed: / / **Orbit #**

Elect. Tech. in Charge:

TAPE SPEED	1 7/8	3 3/4	7 1/2	15	30	60	120
FR-600							
FR-100							

Recorder					Sync.			Servo			Telemetry Signal				HF-3 Sw. Pos.		Frame Sync.			
Track	Direct	F. M.	P. D. M.		Recorder	Comb Filter AGC	Voltage Level	Line	Channel No. 2	Voltage Level	Good	Questionable	Poor	Voltage Level	10 K.C.	100 K.C.	Voltage Level	Stable	Unusable	Change of Servo
1																				
2																				
3																				
4																				
5																				
6																				
7																				

Recorder & Time Mode		Playback Quality of Tape						Equipment Failure											
Analog Tape Time Stop _____ Start _____ ELAPSE Digital Time ELAPSE Start Time:		Loss of Signal	Fading of Signal	Poor Signal	Noisy	Loss of Sync.	Interference	Tracking Filter	A. D Converter	Buffer	Transports and associated electronics	Comb Filter	Sync. Equipment	Phase Lock Osc.	Time Decoder	Ministrack Station		Time Difference	Remarks
Stop	Start																		

Remarks from Analog Tape Log:

Remarks from Evaluation Tape Log:

Remarks from A D Operation:

Remarks from D/D Editing:

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Figure 15. Analog-to-Digital Processing Log

ANALOG TO DIGITAL SUMMARY

BUFFER TAPE # LINE # SATELLITE #

FILE NUMBER	ANALOG TAPE NUMBER	STATION NAME	DATE DIGITIZED	DATE RECORDED	TIME STARTED	TIME STOPPED				

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Figure 16. Analog-to-Digital Summary Form

DATA PROCESSING BRANCH

Project # _____ Date _____

BUFFER #	FILE #	EDIT #	FILE #	DECOM #	RUNNING TIME START HOURS	RUNNING TIME FINISH HOURS	ELAPSE TIME HOURS	COMMENTS	OPER INITIALS

Figure 17. Computer Scheduling Form

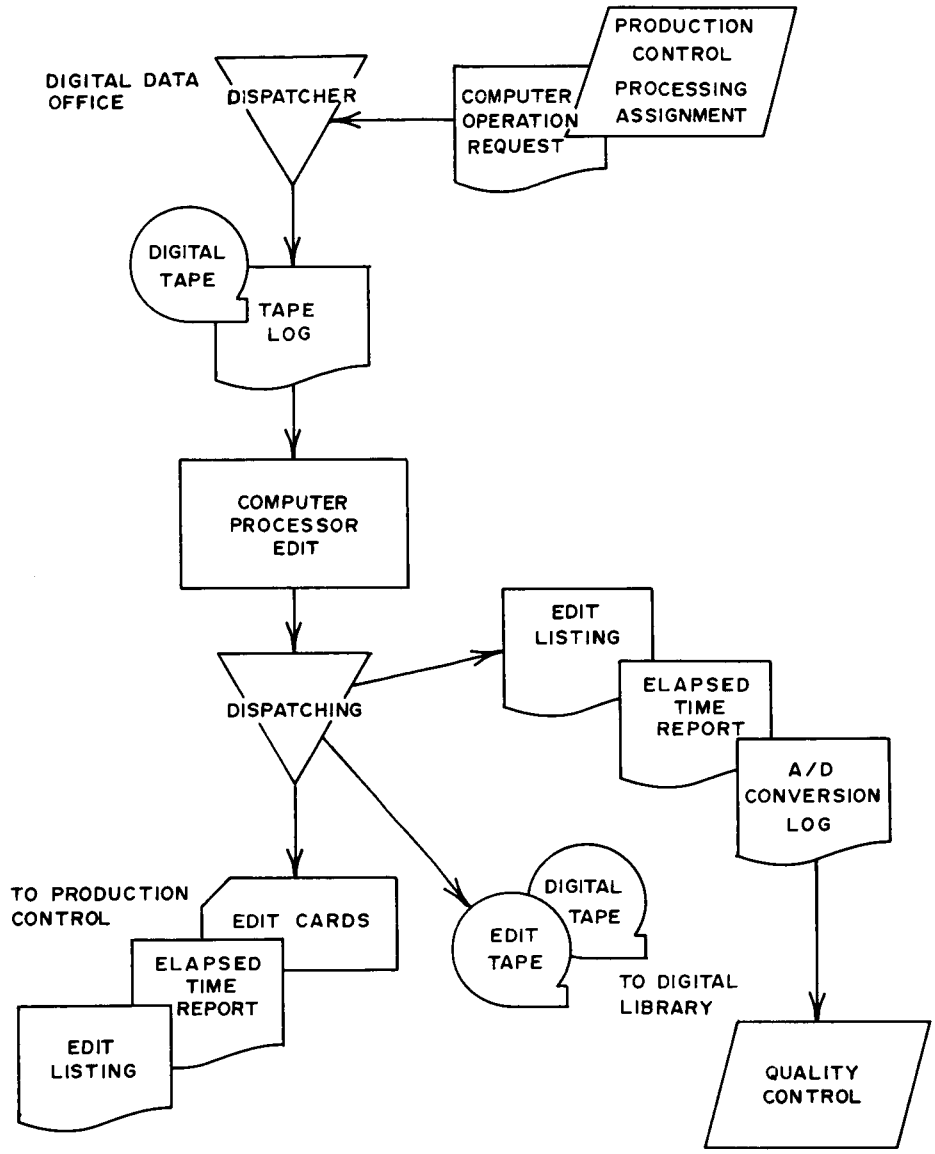

Figure 18. Digital Data Accounting Operations

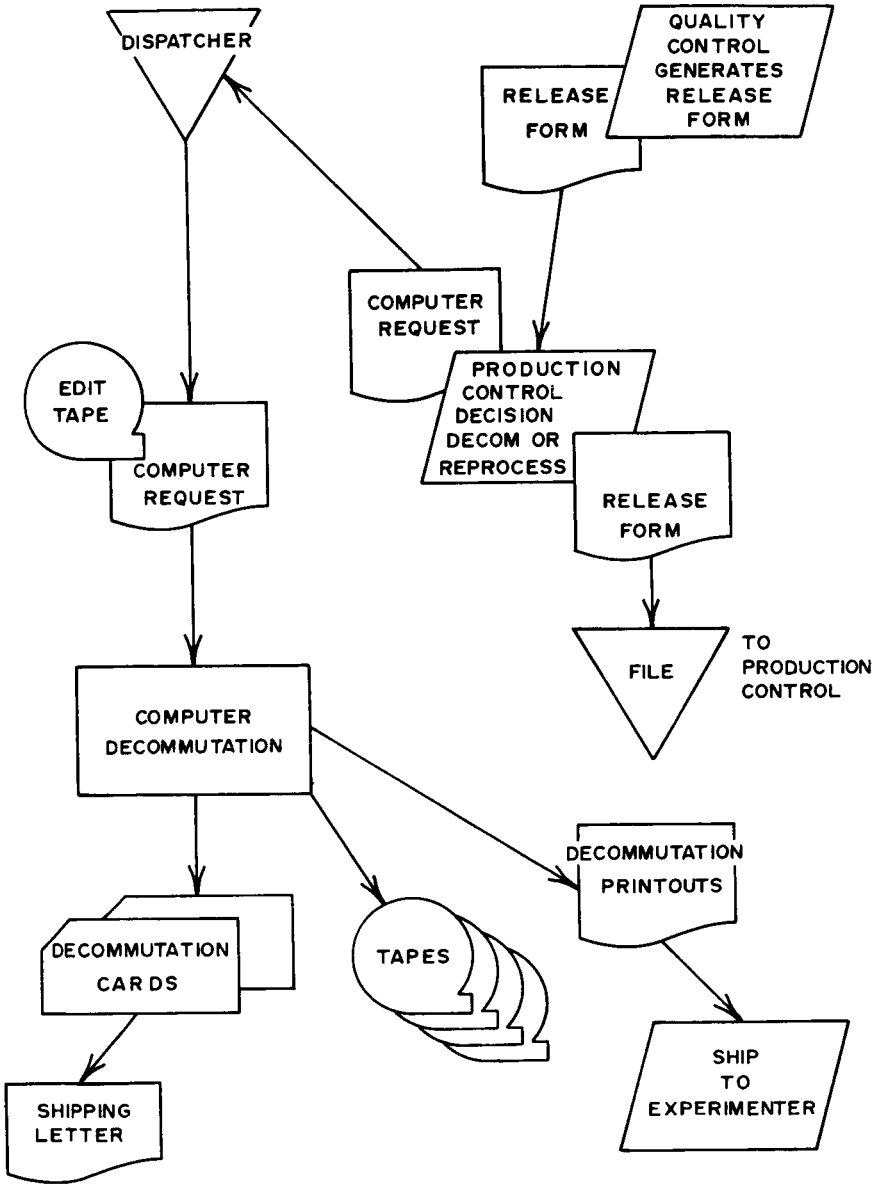

Figure 19. Digital Data Accounting Operations

Data Edit

The dispatcher releases the tapes and logs to the computer room and makes an entry into the buffer tape log form (Figure 20). After an edit tape has been made from the digital tapes, the tapes and the analog-to-digital conversion logs are returned to the Digital Data Dispatcher. They are accompanied by the edit outputs that have been generated. The edit material consists of the edit tape, three copies of edit listings and machine punched edit cards (Figure 21) for each file on the edit tape.

The dispatcher records the date the buffer tapes were processed in the buffer log book. One copy of the analog-to-digital conversion log is retained. The edit output material is then distributed. Buffer and edit tapes are sent to the digital data tape storage area. A copy of the edit listing and an elapsed time report are sent to the Quality Control Group for data inspection. The punched edit cards, a copy of the edit listing and the elapsed time report go to Production Control. A keypunch instruction sheet and the machine punched edit cards are sent to the keypunch section by Digital Data Accounting to update the cards after Quality Control examines the data and finds it to be acceptable and it is released by Production Control. (If a file is rejected, Production Control decides upon a rerun or deletion of the file. The card is destroyed if the file is deleted.) The copy of the edit listing is retained and filed in the Digital Data Accounting Office.

The edit tape number, the orbit number, the sequence number of the file on a card, the buffer tape number and the conversion date are punched during the computer edit run and edit dates are added by the keypunch operator. The cards are listed and checked by Production Control prior to updating. This is done to determine if the edit run was performed satisfactorily. An updated edit card is shown in Figure 22.

The updated edit cards are placed in the suspense file in the Digital Data Accounting Office. A listing of the updated edit cards is held in the Production Control Center for reference.

Decommutation

A data inspection group performing quality control determines if edit files should be decommutated on the basis of established quality standards. An Edit Release Form (Figure 23) with data inspection information is sent to the Production Control Center.

DATA PROCESSING BRANCH
PRODUCTION LOG

SATELLITE _____ SYSTEM _____ DATE _____

INPUT

TELEMENTRY ACQU. DATA

Station _____ No. _____
Date Recorded _____ Telementry Format _____
Tape No. _____ Satellite Format _____
Pass No. _____ Bit Rate _____
Tape Speed – 1 7/8 3 3/4 7 1/2 15 30 60 120

TIME INFORMATION

Start _____ : _____ : _____
Stop _____ : _____ : _____
Elapsed _____ : _____ : _____

ANALOG MEDIA

Film No. _____ Size _____
Strip Chart No. _____ Speed _____
Graph No. _____ Size _____
Photo No. _____ Size _____
Other _____

DIGITAL MEDIA

Punched Paper Tape No. _____
Card Type _____ File No. _____
Magnetic Tape No. _____ File No. _____
Other _____

OUTPUT

ANALOG MEDIA

Film No. _____ Size _____
Strip Chart No. _____ Speed _____
Graph No. _____ Size _____
Photo No. _____ Size _____
Other _____

DUPLICATION MEDIA

Film – No. Copies _____
Strip Chart – No. Copies _____
Graph – No. Copies _____
Photo – No. Copies _____
Tape – No. Copies _____

DIGITAL MEDIA

Punched Paper Tape _____
Card Type _____ File No. _____
Magnetic Tape No. _____ File No. _____
Tape Serial No. _____
Other _____

TIME INFORMATION

Start _____ : _____ : _____
Stop _____ : _____ : _____
Elapsed _____ : _____ : _____

OPERATION RECORD

REPRODUCE TRANSPORT

A. Tape Transport Speed – 1 7/8 3 3/4 7 1/2 15 30 60 120 I.P.S.
B. Servo Control – Prec. Freq. ☐ Line ☐ Coil Track ☐ Other ☐
C. Servo Performance – Excellent ☐ Good ☐ Fair ☐ Poor ☐

TIME SYSTEM

A. Linearizing Freq. In Use? Yes ☐ No ☐
B. Time Code Used – BCD ☐ SD ☐ BCD&SD ☐ Accum. ☐ None ☐ Other ☐
C. Time Quality – Excellent ☐ Good ☐ Fair ☐ Poor ☐

TELEMENTRY PROCESSING SYSTEM

A. Sync Source – Rec. Agc ☐ C.F. Agc ☐ Telementry Sig. ☐ Other ☐
B. Sync Counter – In _____ Out _____
C. Sync Performance – Excellent ☐ Good ☐ Fair ☐ Poor ☐
D. Telementry Signal Quality – Excellent ☐ Good ☐ Fair ☐ Poor ☐
E. Discriminator Used – 210 ☐ 97 ☐ 189 ☐ Other _____
F. Tape Speed Compensation in Use? Yes ☐ No ☐
G. System Calibrated Prior to this Run? Yes ☐ No ☐

COMPUTER SYSTEM

A. Tape Density – High ☐ Low ☐ Other _____
B. I.D. Error – Yes ☐ No ☐
C. Tape Parity Errors – Yes ☐ No ☐ Est. No. _____
D. Block Length – Standard ☐ Other _____
E. Record Length – Standard ☐ Other _____
F. Output Tape Unit – 729 ☐ 906 ☐ Other _____

OPERATOR COMMENT

_____
_____
_____
_____

OPERATOR _____ CODE _____

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Figure 20. Buffer Tape Log Form

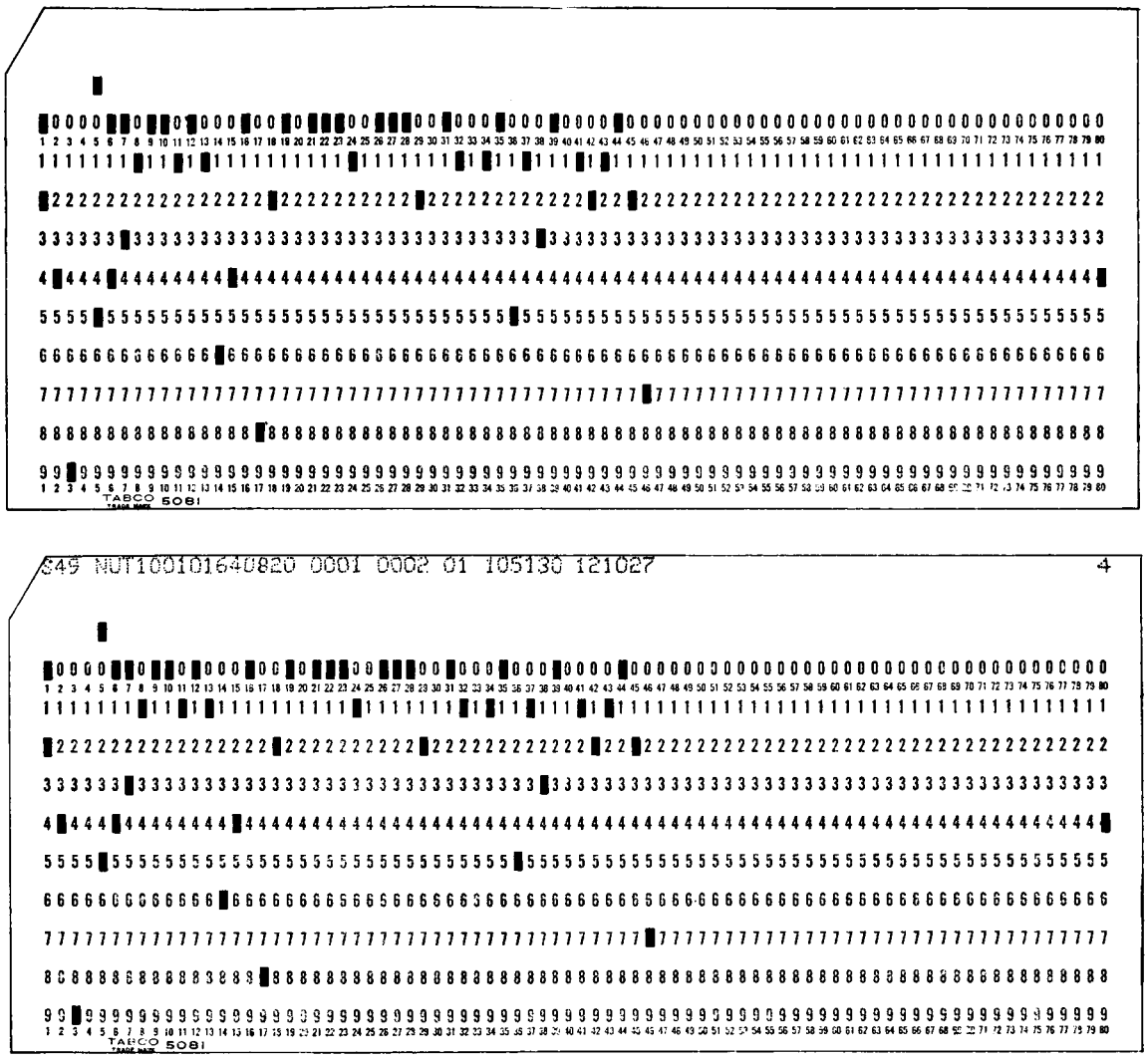

Figure 21. Machine Produced Edit Card and Keypunch Copy with Printed Line Added

The Production Control Center schedules the decommutation runs and sends a request to the dispatching office to send edit tapes to the computer room. The Digital Data Accounting Office files the edit cards in the suspense file until the weekly updating of the master accounting tapes is performed.

After decommutation is finished, the edit tapes are returned with decommutation material to the Digital Data Dispatching Office. The material consists of (1) decommutation tapes for each experiment, (2) decommutation printouts, and (3) an experimenter documentation card. The dispatcher returns the edit tapes to the digital tape storage and holds the decommutation data in temporary storage

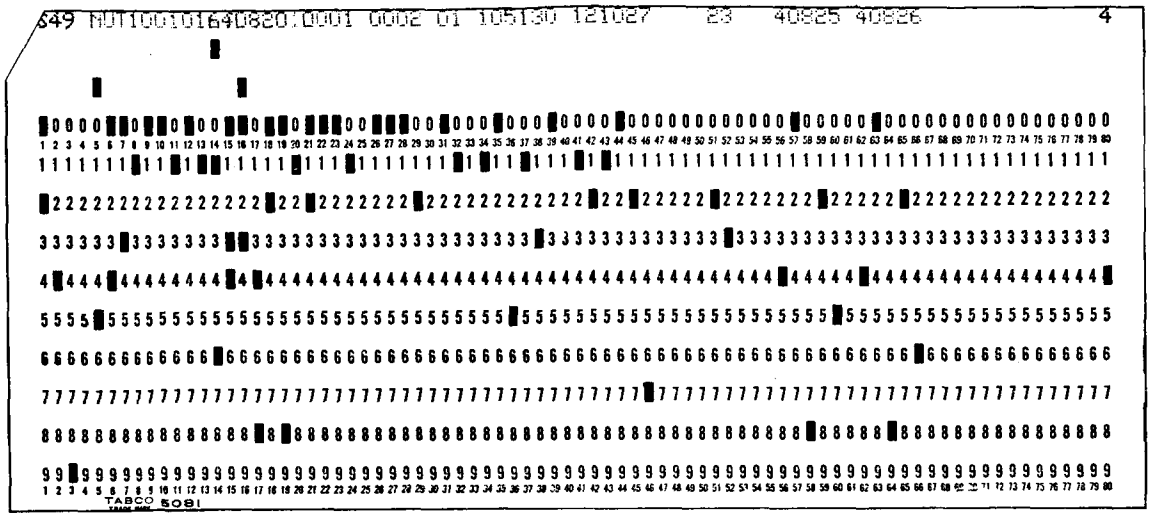

Figure 22. Updated Edit Card Through the Edit Field

pending release by the data inspection group prior to shipment. The decommutation printouts to be sent to experimenters are routed to the data inspection group in Quality Control. The Digital Data Accounting Office sends the experimenter documentation cards to the Production Control Center which lists and verifies their contents. The cards are then returned to the Digital Data Accounting Office which has a shipping letter created through a computer run. Decommutation and shipping data is punched in the edit cards (Figure 24). The edit cards are once again returned to the suspense files for use in the weekly update of the master file tape.

The data inspection group releases the decommutation tapes for shipment to the experimenters and sends a report to the Production Center which in turn forwards a release for shipment to the Digital Shipping and Receiving Office. Edit cards are removed from the files and the shipping data is punched in them (Figure 25).

The decom cards are used by a computer to make three copies of a shipping letter (Figure 26) which lists each file on a decommutation tape. The experimenter receives two copies of the shipping letter and returns one with signature acknowledgement of receipt to the Digital Shipping Office.

The Shipping Office prepares a magnetic tape receipt in triplicate (Figure 27) for each tape. One copy is held and two copies accompany the tape. One copy is returned from the receiving experimenter upon receipt of the tapes.

EDIT RELEASE FORM

Project	Date	Edit No.	File No.	ID of Rejected File	Start Time	Reason for Rejection	Date Ship'd	Remarks

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Figure 23. Edit Release Form

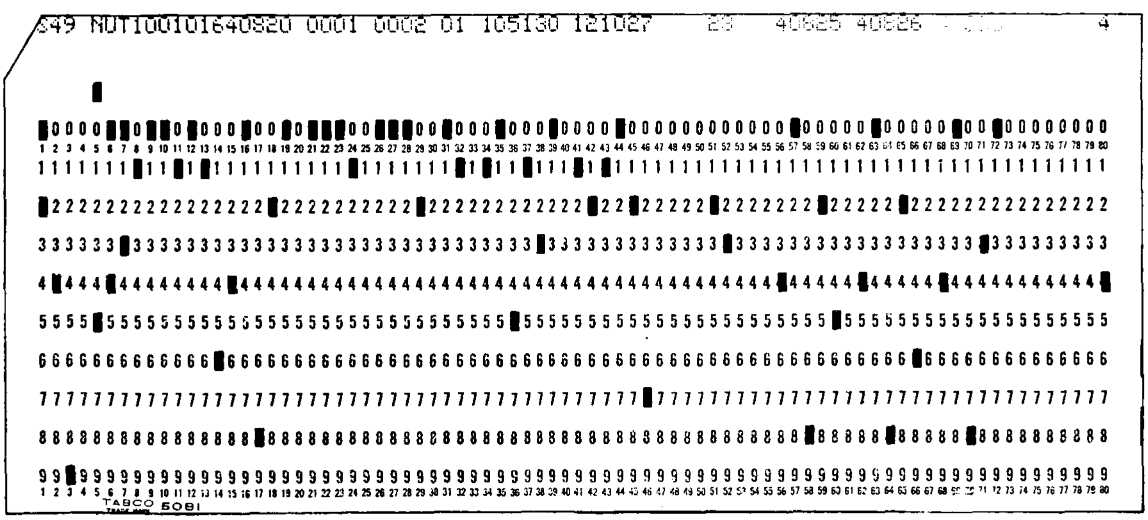

Figure 24. Updated Edit Card Through the Decommutation Field

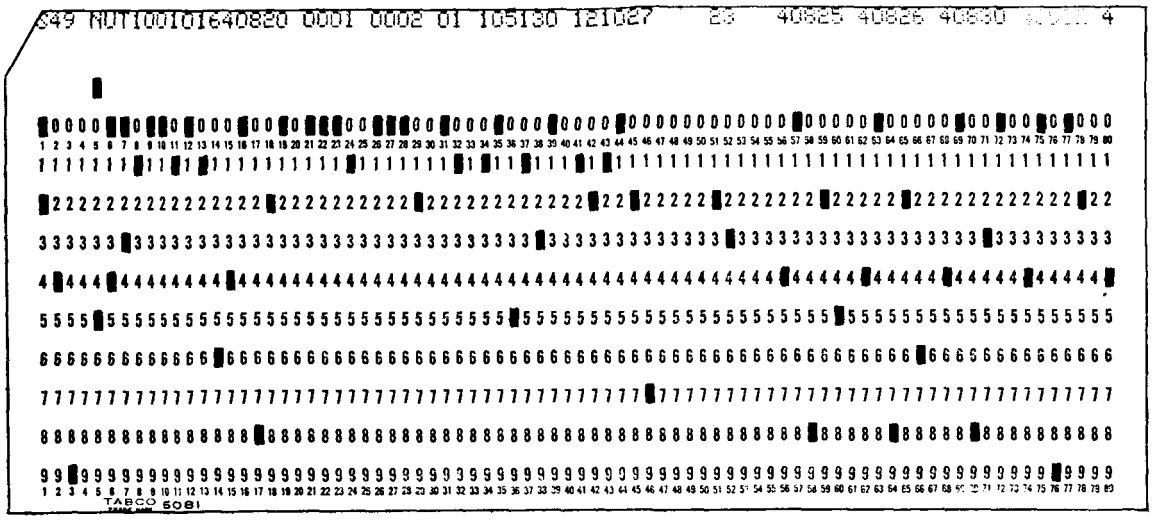

Figure 25. Updated Edit Card Through the Released Field

After the decommutation tapes have been shipped to the experimenter the production cycle is completed and the digital buffer tapes are erased.

QUICK LOOK REQUESTS

At times, rapid assessment of digitized data is needed. When such a case arises, a "quick look" buffer tape and an analog-to-digital conversion log form are given to the Digital Data Dispatching Office. No formal accounting takes place for this process.

PLEASE ACKNOWLEDGE RECEIPT OF THE FOLLOWING AND RETURN THIS FORM TO

DIGITAL DATA ACCOUNTING OFFICE
DIGITAL DATA CONTROLLER
NASA GODDARD SPACE FLIGHT CENTER
CODE 545
GREENBELT,MD. (20771)

1 OGO EXPERIMENTER DATA TAPES

STA	TAPE	FILE	RECORDED YR	MO	DY	PASS	EDIT TAPE	EDIT FILE	START HR	MN	SC	DECOM RUN	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	EXP 7	EXP 8	EXP 9	EXP 10
ROS	010	01	64	08	01		2301	01	15	53	35	05	10 01	10 01	10 01	10 00	10 01	10 01	10 01	10 01	10 01	10 01
ROS	010	02	64	08	01		2302	01	15	58	01	05	10 02	10 02	10 02	10 00	10 02	10 02	10 02	10 02	10 02	10 02
ROS	010	03	64	08	01		2303	01	16	02	19	05	10 03	10 03	10 03	10 00	10 03	10 03	10 03	20 01	10 03	
ROS	010	04	64	08	01		2304	01	16	16	47	05	10 04	10 04	10 04	10 00	10 04	10 04	10 04	10 04	20 02	10 04
ROS	010	04	64	08	01		2305	01	18	12	03	05	10 06	20 01	10 05	10 00	10 05	10 05	10 05	30 01	10 05	
ROS	010	05	64	08	01		2306	01	18	21	18	05	20 01	20 02	10 06	10 00	20 01	10 06	20 01	10 06	30 02	20 01
ROS	010	06	64	08	01		2307	01	18	34	49	05	20 02	20 03	10 07	10 00	20 02	20 01	20 02	20 01	40 01	20 02

X NO OF FILES 7

DATE RECEIVED SIGNATURE

Figure 26. Shipping Letter Sent to Experimenters

SATELLITE_____ EXPERIMENTER _____

Please sign and return this receipt to code 564.

DESCRIPTION	INVENTORY	EDIT	DESCRIPTION	INVENTORY	EDIT

PLEASE NOTE ANY DISCREPANCIES
OR DAMAGE

Date

Signature

GSFC 22-6 (8/65)

Figure 27. Receipt for Magnetic Tapes

PRODUCTION CONTROL AND ACCOUNTING SYSTEM

The current accounting system employed by the Data Processing Branch has three main storage elements. They are an analog card library, a digital card library and a magnetic tape master storage file.

The proposed Production Control And Accounting System (Figure 1) will incorporate all these areas into one operational and storage facility. All the data contained on the punched cards and on magnetic tape will be available in a disk storage file.

All information needed for production control decision making, all data required for accounting purposes, and all data used for the various listings will be readily accessable for call up by the system. The strength of this system resides in the availability of the data. Operations required for the sorting and merging of data in order to update and reformat files of information will be reduced. Program effort will be directed towards more qualitative types of operations because of the virtual elimination of data manipulation routines.

PROCEDURAL MODIFICATIONS

The present procedures can be modified in the following manner when the Production Control and Accounting System is placed into operation.

Analog Documentation

One set of analog tape documentation cards (Figure 8) can be generated instead of two when the cards are created. The information on the cards can be inserted into a random access, mass disk storage file through an input station of a data collection system when a small number of cards are to be stored. When there are a large number of cards containing data to be stored the cards can be inserted through a high speed card reader connected to a central processor unit.

The set of punched cards ordinarily held by the Analog Accounting Office need not be retained once the punched card information has been stored on the disk. (Cards should be temporarily retained until a weekly magnetic tape duplicate the master file on the disk is made. This redundant operation is performed to guard against the possibility of information damage in the master file. If the cards were discarded immediately no records would be available.) A set of cards will be forwarded to Production Control if they are to be used for computer inputs at a later time. If not, they can be discarded after initial entry of the data.

Storage Medium Change

By changing the storage medium from punched cards to a random access, mass storage medium the need for maintaining a card suspense file is eliminated. The manual steps of entering, arranging and removing cards is no longer necessary. In the case of the analog documentation card, the entries after tape evaluation, analog to digital conversion, and final processing can be inserted directly into the random access storage from an input station.

Weekly Station-by-Station and Chronological Listings

The weekly station-by-station listings (Figure 9) developed on magnetic tape from the analog documentation cards can be called for directly from a central processor which will extract the required data from storage and print it on a high speed printer. The weekly chronological Analog to Digital listing, which is now obtained by sorting the master tape, can also be acquired directly from the disk file for output. This function can be performed under message control from the Production Control Office.

Edit

Cards produced by a computer during an edit run must be updated after the process, after decommutation of data and when all work is complete and tapes are released for shipping. They are used to produce listings and to supply digital data information to be placed on the master accounting tape. A substantial amount of card punch work is conducted by electronic accounting machine operators, and the card suspense files must be referenced many times.

The Production Control System will use the edit cards for initial entry of digital data and then the cards can be discarded after a temporary holding period. The subsequent updating, necessary listings and use of the accounting data for the master accounting tape can be extracted from the disk storage file.

Decommutation

Decommutation cards are punched at the time the experimental data is separated by computer processing. These cards are checked and updated for the purpose of creating shipping letters and for updating the master accounting tape.

In the Production Control System the decommutation data on the cards will be entered immediately into the disk storage by use of an input station in a data collection system. All information put in to update a card will be keyed in or

referenced, through an input station, and shipping letters will be printed out when the Production Control Center directs personnel operating the central processor to do so. The decommutation cards can also be removed from use after the data has been entered into the system.

SYSTEM CONCEPTS

The implementation of the Production Control System will eliminate the majority of the card punch operations now being performed. Once operational efficiency has been reached and confidence gained in the system further reductions in the control and accounting process can be undertaken.

A two stage phasing procedure can be carried out to achieve full system performance. The first phase will involve a rearrangement of assignments in the Analog Data Accounting, the Digital Accounting and the Production Control Center offices to realize more effective control. Accounting and listing related to production control activities that are done on other computer systems will be transferred to the Production Control System. Cards will be retained only for unusual program tasks as will magnetic tapes that do not require sort and merging to update data files for record keeping.

The second phase will place greater reliance upon the system. The Production Control Center will make greater use of the system for message transmission to other production elements. System programs will be developed so Production Control can communicate directly with the central processor to generate whatever data it desires, rather than transmitting a coded request for operational personnel on the central processor to call forth a program to perform the task. When operational capability has been proven and an accurate assessment made, the centralized control functions can be distributed to other operational elements and the input and output stations added accordingly in order to accommodate them.

SYSTEM EQUIPMENT

The Production Control System is shown in Figure 28. The system consists of the IBM central processor, a 1311 disk storage file of six million characters; expandable to eight million characters; four 729 Mod IV digital tape drives, a 1402 card reader/punch, a 1403 high speed printer, a 1026 transmission control unit to connect the central processor to data collection stations, six 1031 input stations and four 1033 output printer stations. The purpose of each piece of equipment will be described in the paragraphs to follow.

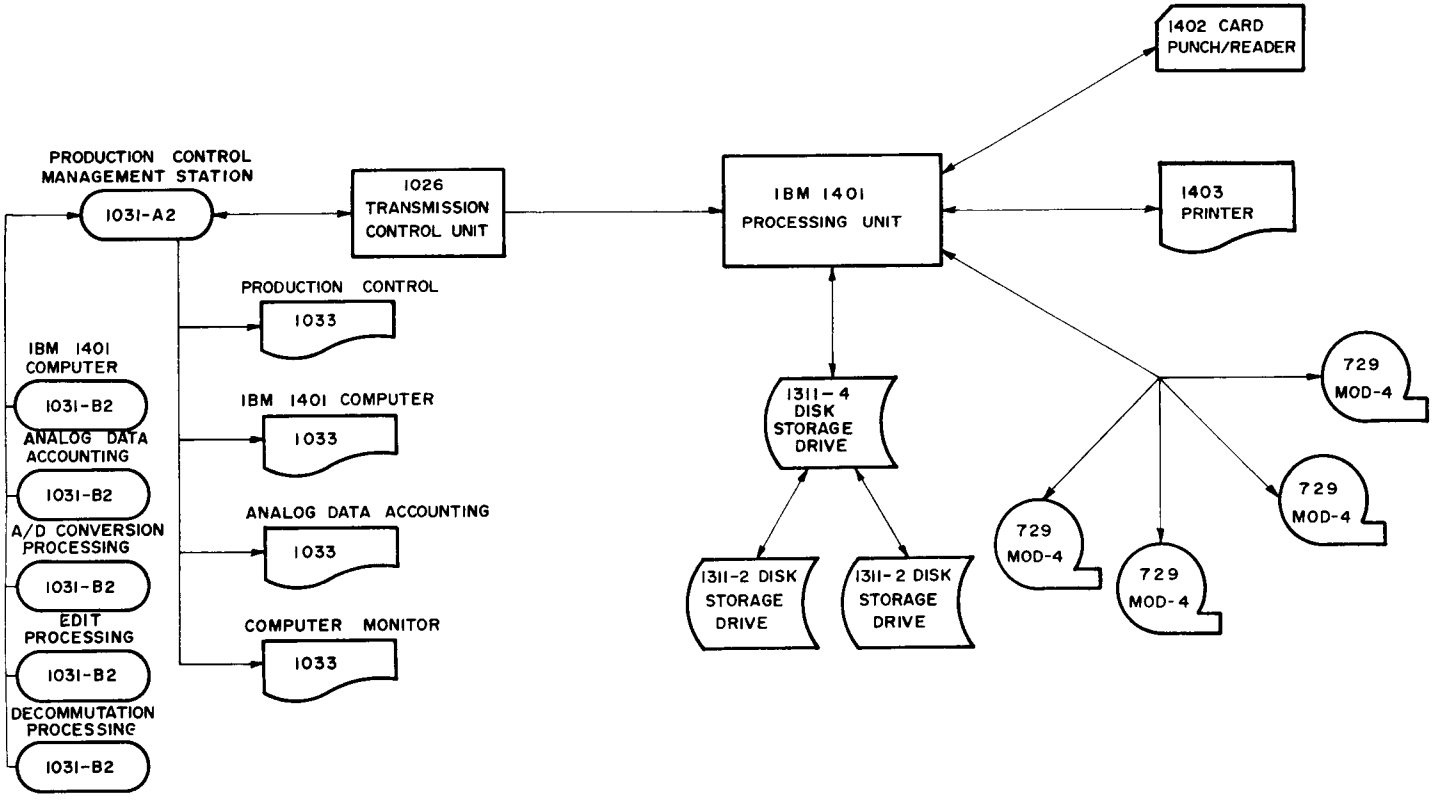

Figure 28. Production Control Accounting System 1030 Data Collection Equipment Assignment

The total storage capacity of the disk storage drive is 6 million characters. The locations in excess of the amount used for accounting data will be used for related statistical information and for program routines for the Production Control System.

IBM 729 Mod IV Digital Tape Drives

The magnetic tape drives (Figure 31) will be used for a variety of support activities. To augment the Production Control System, one tape unit will contain a master executive library tape for programs stored in the disk storage drive plus auxiliary programs for processing related to the system. This will include programs that perform statistical analysis and tabulations on the accounting data. The other magnetic tape units will be used to record completed files of individual satellites and as an extension to the master file for data removed from disk storage because of satellite inactivity. The tape drives can be operated with magnetic tapes recorded at 200 and 556 characters per inch.

IBM 1402 Card Punch/Reader

The 1402 card punch/reader will be used for reading large quantities of punched cards when initial entries of analog and digital documentation data are loaded into the Production Control and Accounting System disk storage drive. It will also be used for punched card generation when needed. The card punch/reader is illustrated in Figure 32. The 1402 reads cards at a speed of 800 per minute and will punch 250 cards per minute.

IBM 1403 Printer

The IBM 1403 printer is illustrated in Figure 33. It will be utilized as the principal source for all outputs. This will include immediate printouts of single files, or groups of files for any, or all satellites. It will also include the station-by-station listings, analog to digital chronological listings, random, daily and weekly summary reports on the status of the satellite data in the different processing stages. The printing speed of the 1403 is 600 lines per minute with up to 130 characters per line.

IBM 1031 Data Collection Input Stations

The input stations (Figure 34) will be the entry points for accounting data set into the disk storage master file. They will be used as the point of origin for message communications and for instructions between the Production Control Center and the other operational areas of the Production Control and Accounting System organization. There will be six input stations available in four areas

IBM Central Processing Unit

The IBM 1401 is a programmed controlled digital computer. (Figure 29) It will route data and messages between data collection stations. It will order, load and retrieve data from the disk storage. It will accept information from the magnetic tape drives and the card reader. Upon command to output, it will send data to be written on magnetic tape, output to the 1403 printer and to the 1402 card punch.

IBM 1311 Disk Storage Drive

The 1311 Disk Storage Drive (Figure 30) will be used in the system as a random access master storage for 5.76 million characters of accounting data.

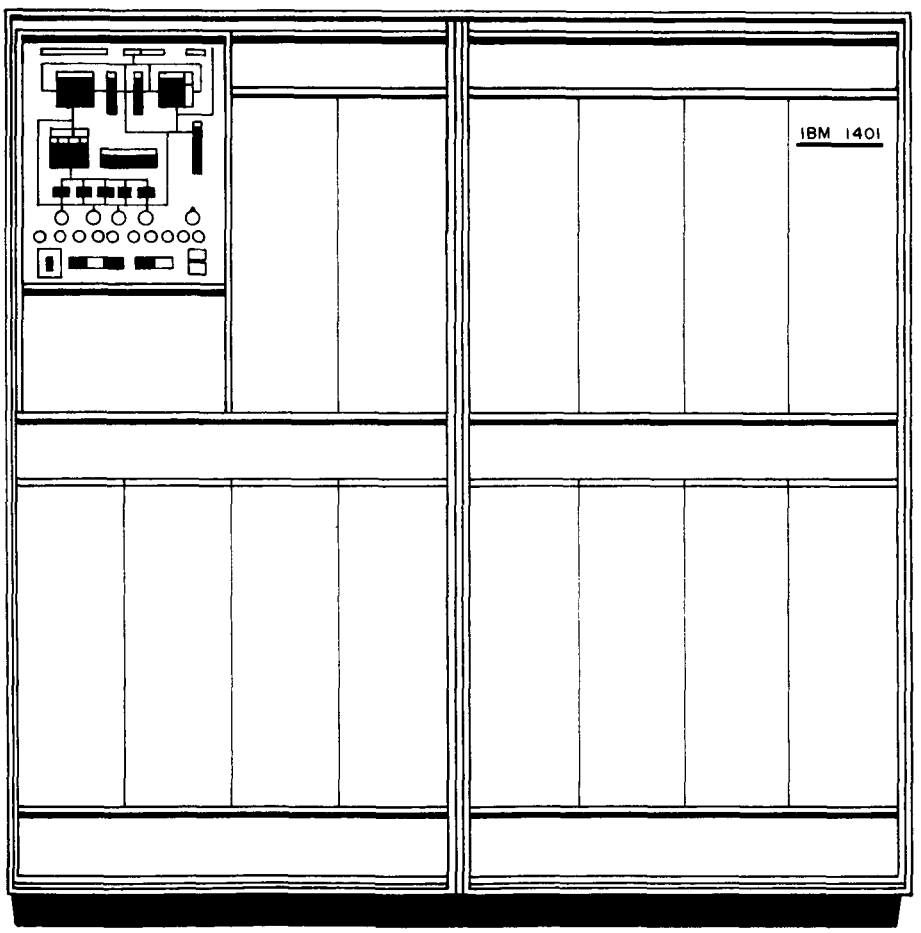

Figure 29. IBM 1401 Processing Unit

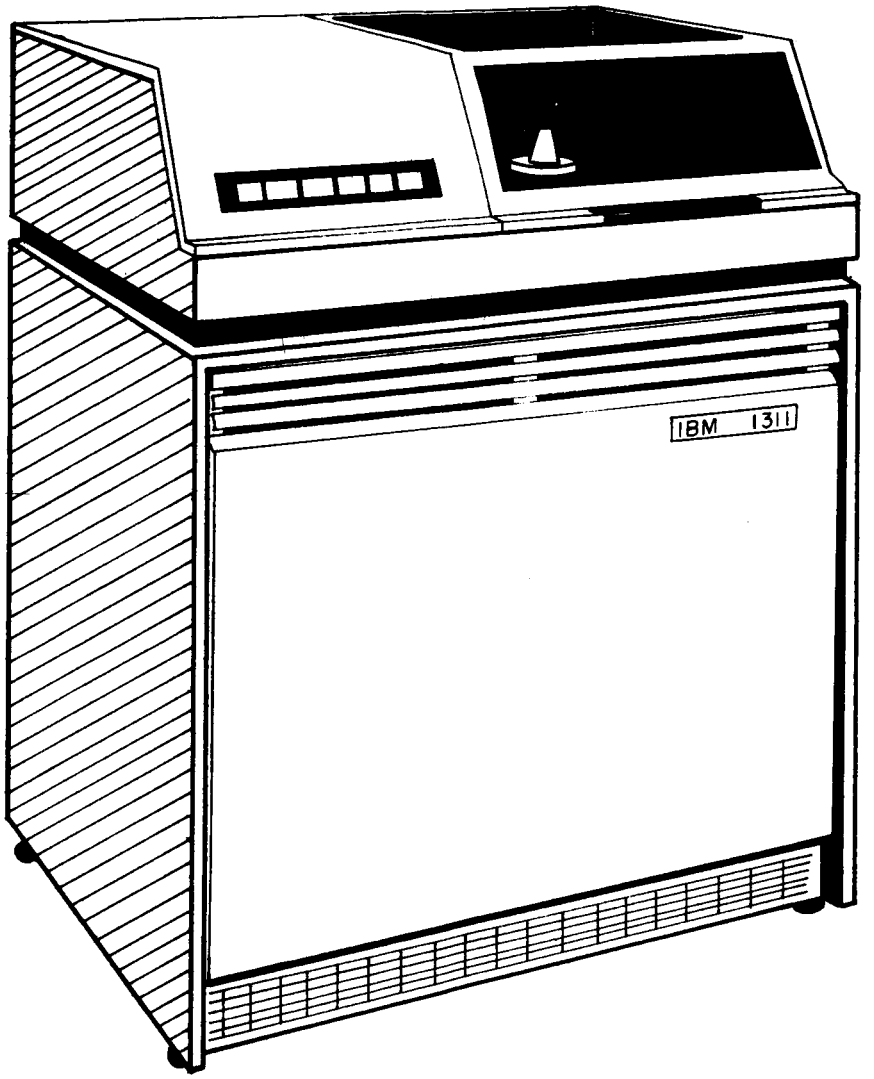

Figure 30. IBM 1311 Disk Storage Drive

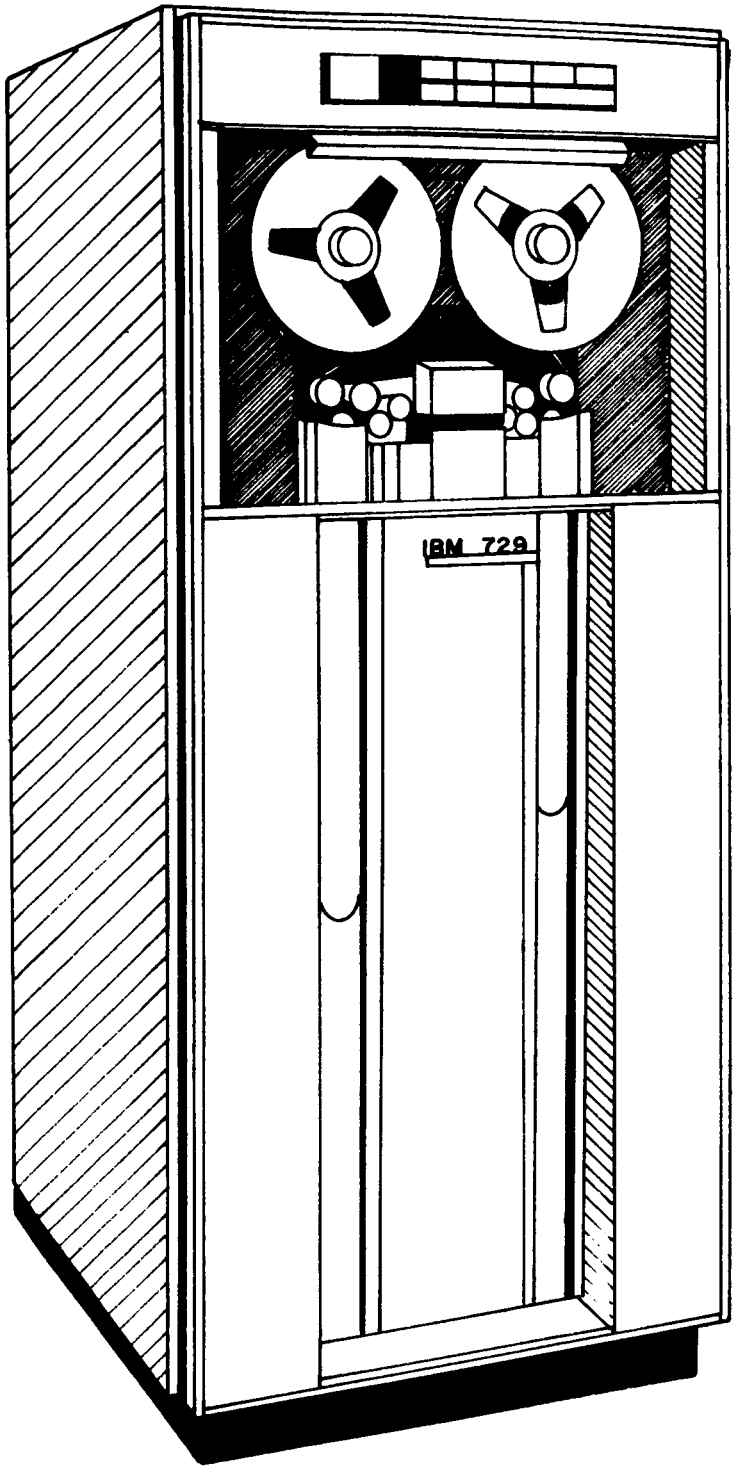

Figure 31. IBM 729 II, IV, VI Magnetic Tape Unit

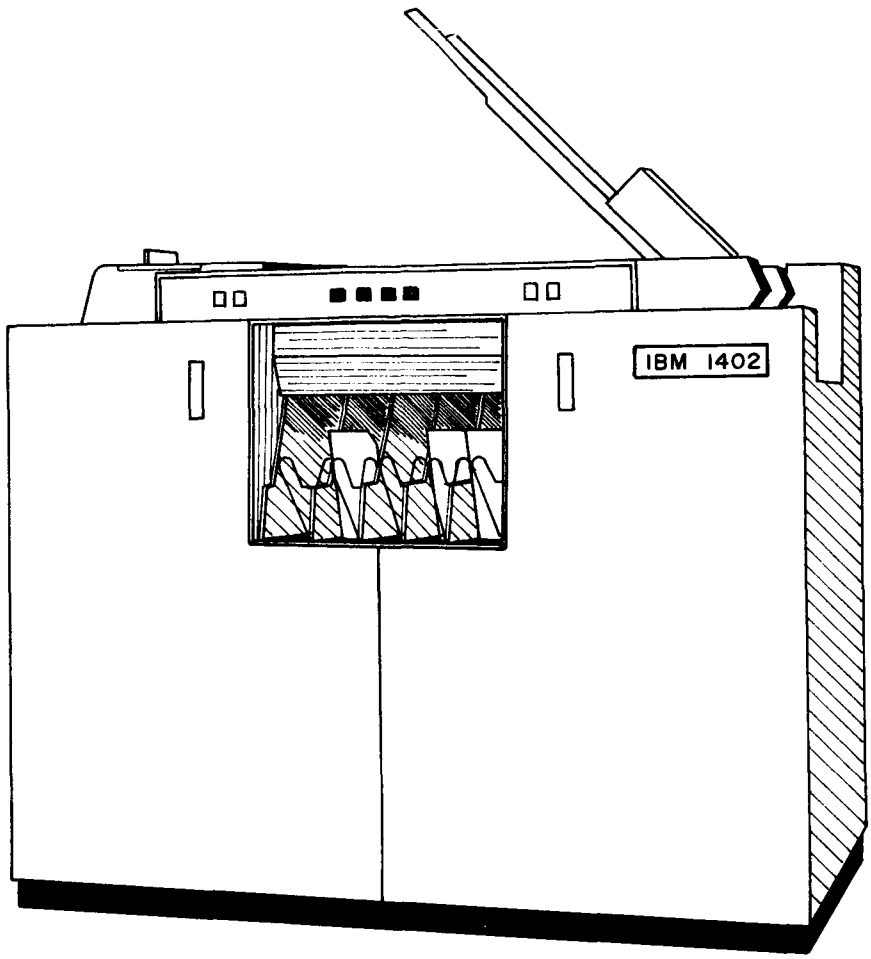

Figure 32. IBM 1402 Card Read–Punch

that must put data into the accounting record storage locations. The input rate from a collection station is governed by a transmission control unit which moves BCD characters at a rate of 60 per second. Inputs will be by use of punch cards or by manually keyed entries.

IBM 1033 Data Collection Output Terminals

There will be four IBM 1033 output terminals (Figure 35) in the system. The terminals can print 130 characters per line at a rate of 14.8 characters per second. These print stations will be used for message control, output of random, compact listings and summary reports by the Production Control Center.

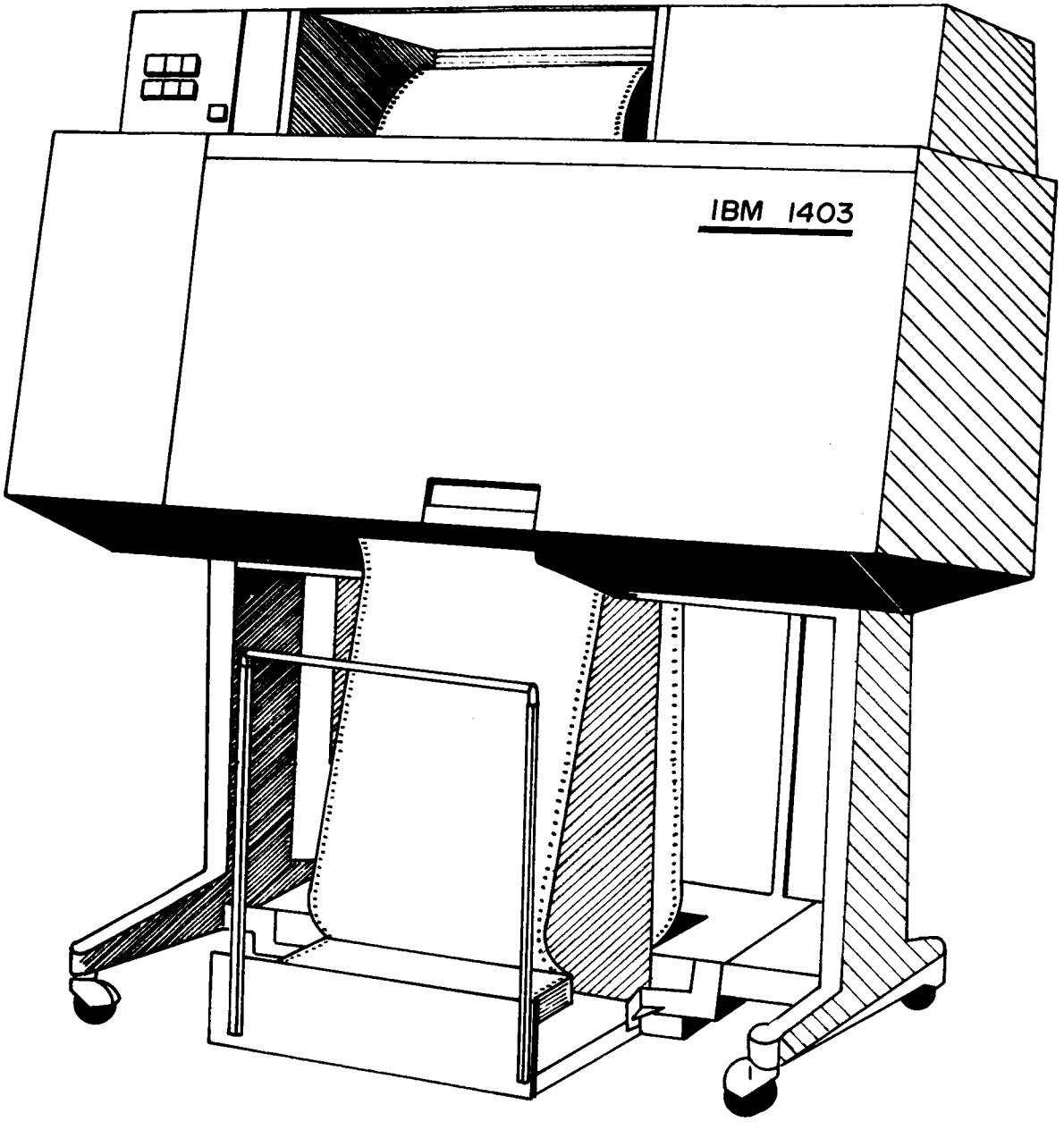

Figure 33. IBM 1403 Printer

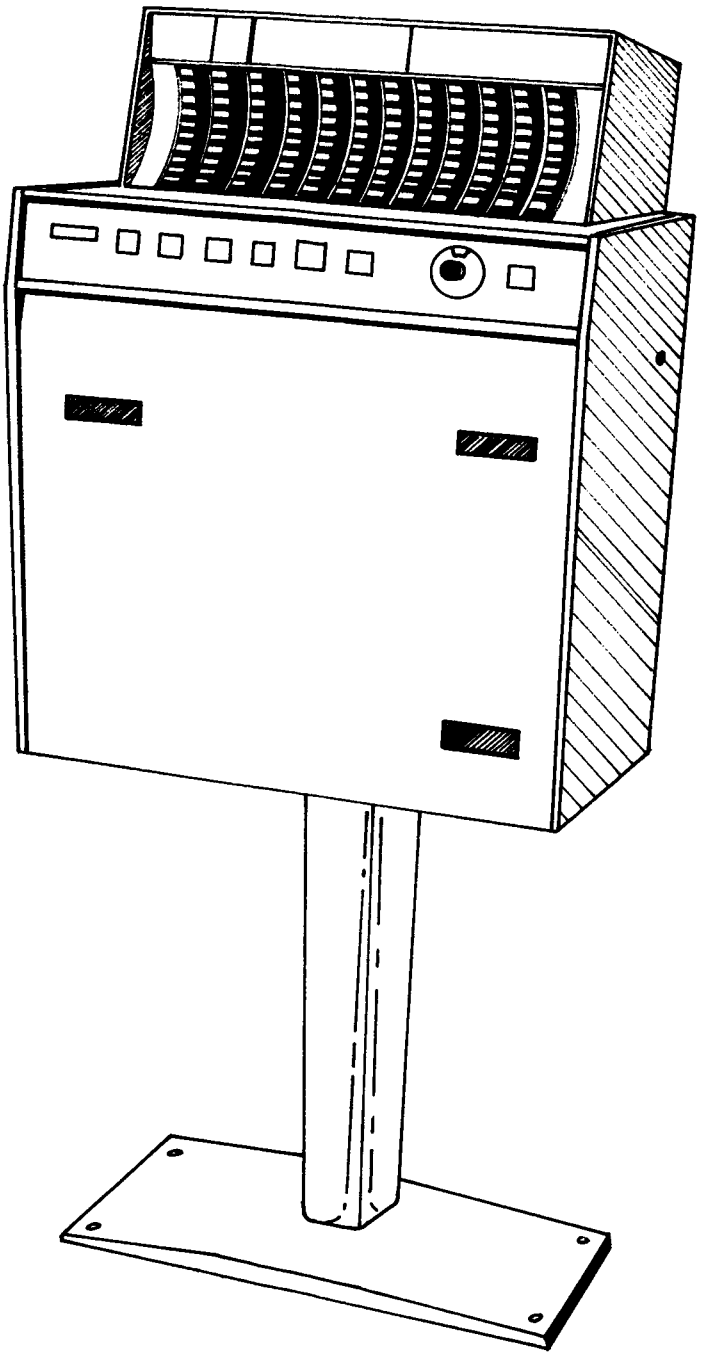

Figure 34. IBM 1031

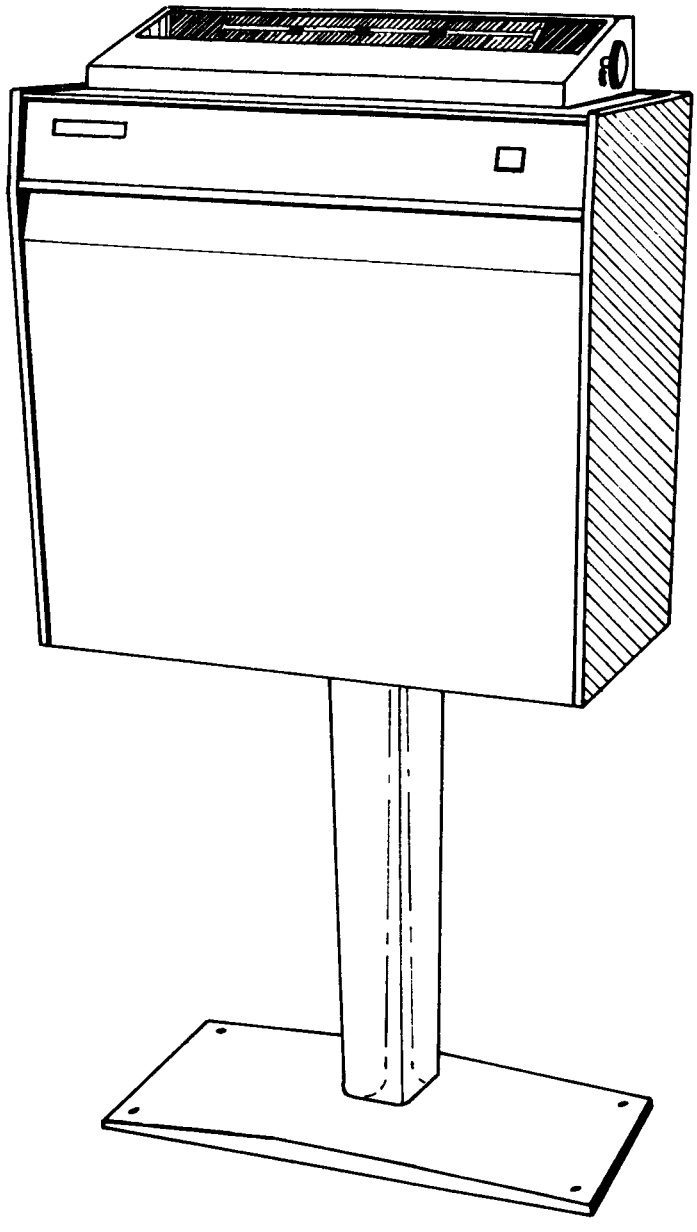

Figure 35. IBM 1033 Printer

IBM 1026 Transmission Control Unit

The transmission control unit (Figure 36) is the control synchronizer for the 1030 data collection input (1031 input station) and output (1033 output printer) equipment. The unit must be connected between the central processor and the data collection portion of the system for synchronized data flow.

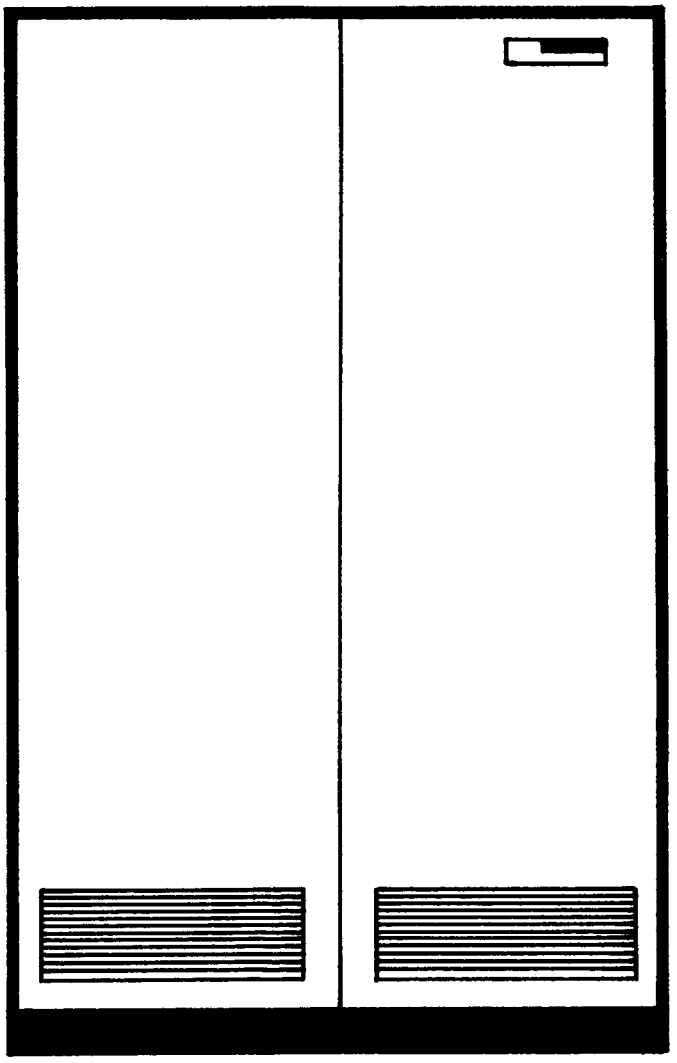

Figure 36. Transmission Control Unit

ACCOUNTING OPERATIONS

The Production Control System will involve a redistribution of current accounting operation activities. The operations depicted in Figure 7, the Analog Data Accounting Operations, Figure 18, the Production Control Center Operations, Figures 19 and 20, Digital Data Accounting Operations will be modified to concentrate decision making and control in Production Control.

Analog Data Accounting Operations

The first change in operating procedure will occur when cards are key punched for information contained in the incoming tape logs. (Figure 37) No duplicate set of cards will be produced. Information on the set of analog documentation cards will be loaded into the disk file from the IBM 1402 card reader when a large amount is to be inserted. Small quantities of cards will be loaded from an IBM 1031 input station.

The initial entry of analog tape accounting data will contain the same 12 fields of information. This consists of:

1. Satellite
2. Station
3. Analog tape number
4. Date of recording
5. Pass number
6. Analog start time
7. Analog stop time
8. Date received
9. Redundancy Code
10. Last file on analog tape
11. Analog file number
12. Card identification symbol

Inserted information will be placed in storage locations assigned to a specific satellite. Every time an initial entry is made an identification field will be picked out by a monitor program which will add a new file to the block assigned for one of the satellites.

Card listings will still be produced by Analog Data Accounting as soon as a set has been completed. An IBM 407 card to printer device is used to perform the listings of the cards which are punched and listed at random intervals. This function can be transferred to Production Control and be performed under program control by the Production Control System but the current method is just as

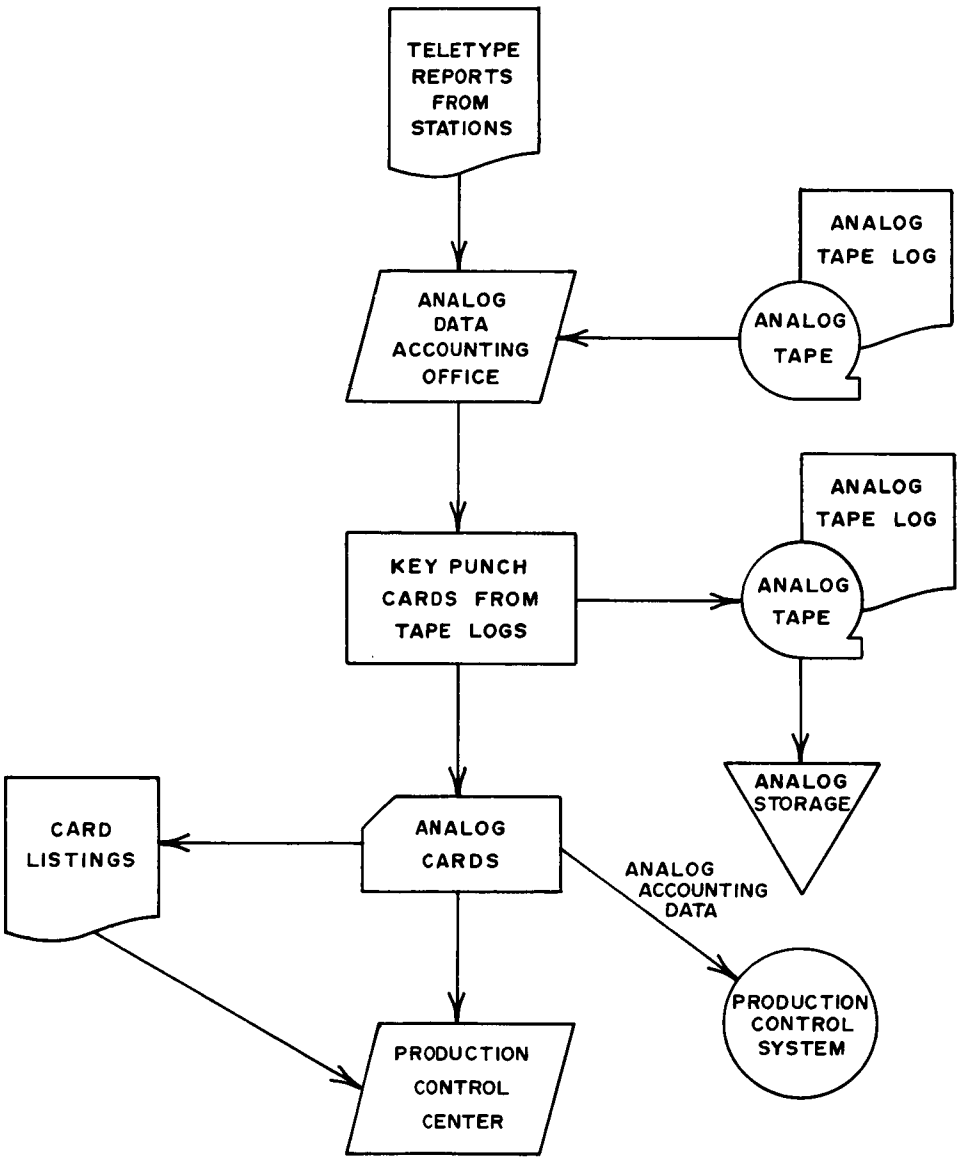

Figure 37. Analog Data Accounting Operations

convenient and the only thing to be gained is a further consolidation of control of the listing functions by the Production Control Center. Since the analog documentation cards are punched by Analog Data Accounting and must be transported to the Production Control Center it is a simple task to perform the listings at that time.

The station by station listings (Figure 9) can be performed at the required weekly interval by the Production Control Center. All comprehensive listings and reports used by Production Control for decision making and those the Center renders for management summary statistics can be called forth by direct program control by using an IBM 1031 input station. This will be the responsibility of the Production Control Center unless it delegates part of the task to other operational elements.

Production Control Center Operations

The Production Control Center operations (Figure 38) start by using the input station of the IBM 1030 data collection system to notify the central processor to print out station by station listings. This can be accomplished by message control to the IBM 1401 operations personnel or by direct program control to the central processor itself. When called upon for the listing, the central processor will extract the required data from the IBM 1311 disk storage drive, print it out on the IBM 1403 when a large output amount is to be printed, or print small amounts of data out by use of the 1033 output station located in the Production Control Center. The selection of which output printer is to be used will be made by a programmed variable.

The Production Control Center will maintain accounting control of the different processing operations. Since this regulation is interspersed throughout the various production phases, the relationship of the Production Control Center will be discussed as each phase is presented.

Analog to Digital Conversion

The Production Control Center will send a tape request to the analog tape library when processing is to take place and the library will send the analog tape along with the tape request to the tape evaluation group, to the analog to digital processing area or to the analog to analog processing area. No change is necessary in the process as it is presently carried out, however, it should be pointed out that the process can be accomplished by using the 1031 input stations for direct communication between the Production Control Center and the analog tape library when tapes are to be removed for processing. When analog to digital conversion is completed, the newly generated digital tape will still be sent to

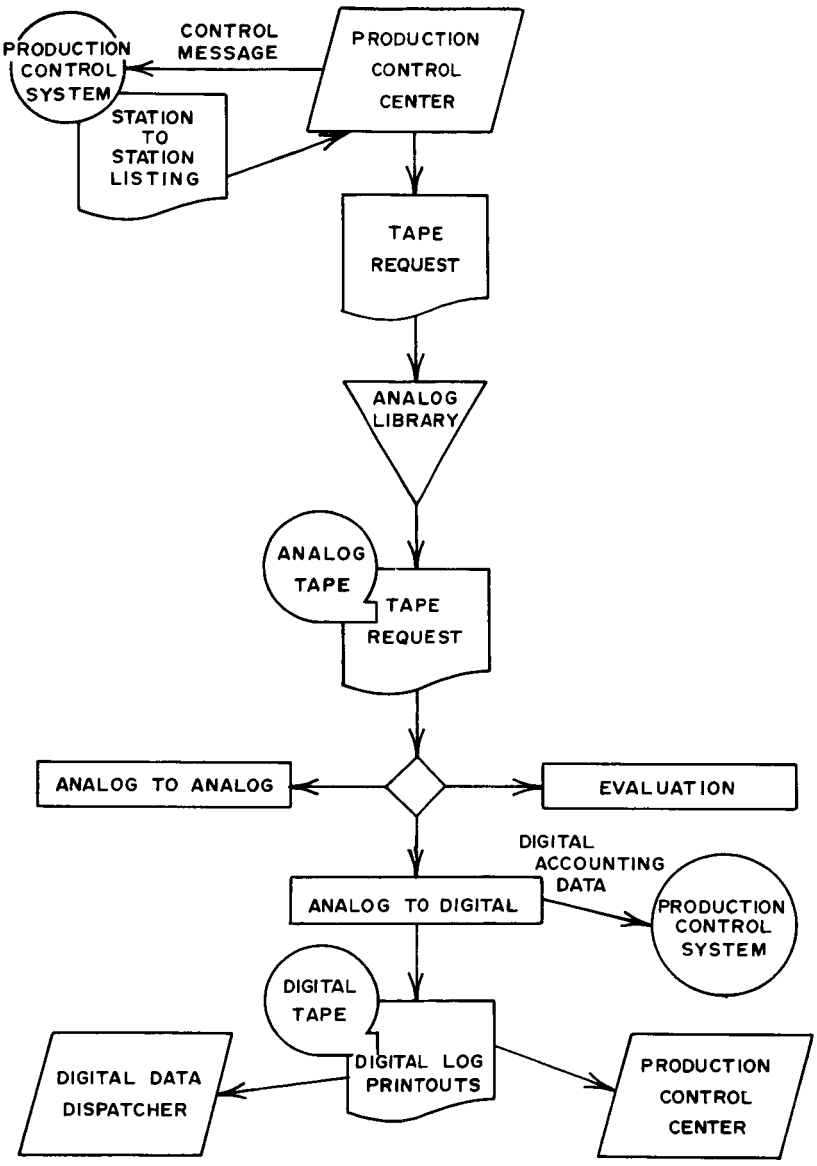

Figure 38. Production Control Center Operations

Digital Data Dispatching and copies of a digital log form (Figure 1-4) will be forwarded along with the tape to be filed and also to the Production Control Center.

Disk File Updating

The first update of the analog documentation card is eliminated at this point. There will be an 1031 input station conveniently located in the analog to digital processing office. The fields of data required are punched in when the analog documentation card is pulled from its suspense file after analog to digital processing on a tape has taken place. This will not be necessary with the installation of the Production Control and Accounting System. The fields can be manually keyed in through a 1031 input station to the accounting master file in disk storage. The time required for this operation will take approximately 30 seconds, the estimated time for a person to set up the 1031 manual input station. The loading time for each character is at a rate of 60 characters per second, the nominal time dictated by the IBM 1026 transmission control unit's character transfer capacity. The information sent into the system will be available for recall as soon as it is stored.

Tape Evaluation

When a tape has been sent to the tape evaluation group to be checked, the Production Control Center has the option to have data quality information punched on cards or to leave the evaluation fields blank. Eight characters are now alloted in the accounting file length for the evaluation quality and for the data evaluated. If it is decided to insert this data, the extraction of the analog documentation card from its suspense file is also eliminated at this juncture. As soon as the Production Control Center has received the evaluation log, the information can be keyed into the production control accounting data storage area of the disk from the 1031 input station.

Computer Processing

The next step in the production process is for the Production Control Center to develop its production schedule which lists the digital tapes to be edited by the computers. This schedule is sent to a Computer Monitoring Group. The Computer Monitor will arrange for the time editing that is to be performed on a computer. The digital tapes are then released by the library in the Digital Data Dispatching Office and sent to the computers when the monitor requests it.

Computer Monitor

The Production Control and Accounting System includes an IBM 1033 output print station located in the Computer Monitor Office. This office will answer only to the Production Control Center. The Production Control Center will communicate with the Computer Monitor by use of the IBM 1031 input station and the 1033 output printer. Tapes to be edited can be listed by manually keying the information into the 1031 input station and special comments can be added by prepunched cards placed into the 1031 input station or by use of numerical codes which can be manually keyed into the system. Once the Computer Monitor Office receives a listing, it will arrange for the time the job is to be performed on a computer and request the Digital Dispatcher to withdraw the digital tapes for editing.

Edit Operations

The task of updating and listing the edit, work now performed by the Digital Data Accounting Office, can be taken over by the Production Control Center (Figure 39). The computer generated edit card, i.e., the digital data documentation card, will be used for storing initial digital data into the disk file via the 1031 input station in Production Control. This operation makes the retention of a digital data card suspense file unnecessary. The update listings can be called for by program control from the Production Control Center by communication with the IBM 1401 central processor.

After editing of a tape is complete and the edit and quality control information is examined, the Production Control Center makes a decision to decommutate data or to call for reprocessing. In either case, the Production Control Center will utilize the IBM 1030 data collection system to relay appropriate instructions to the Computer Monitor.

Decommutation

The decommutation phase of the digital data processing is illustrated in Figure 40. The decommutation of satellite data completes the data processing requirements. Decommutation tapes and corresponding printed material are sent to the scientific personnel involved with the experiments on board the satellites. The cards punched out during a computer run on decommutation data are now used by the Digital Data Accounting Office to produce a shipping letter. Under the proposed system, this responsibility can be transferred to the Production Control Center. The data on the decommutation card can be entered into a reserved file on the disk storage from the 1031 input station and the shipping letter printed out by message request or program control by use of the

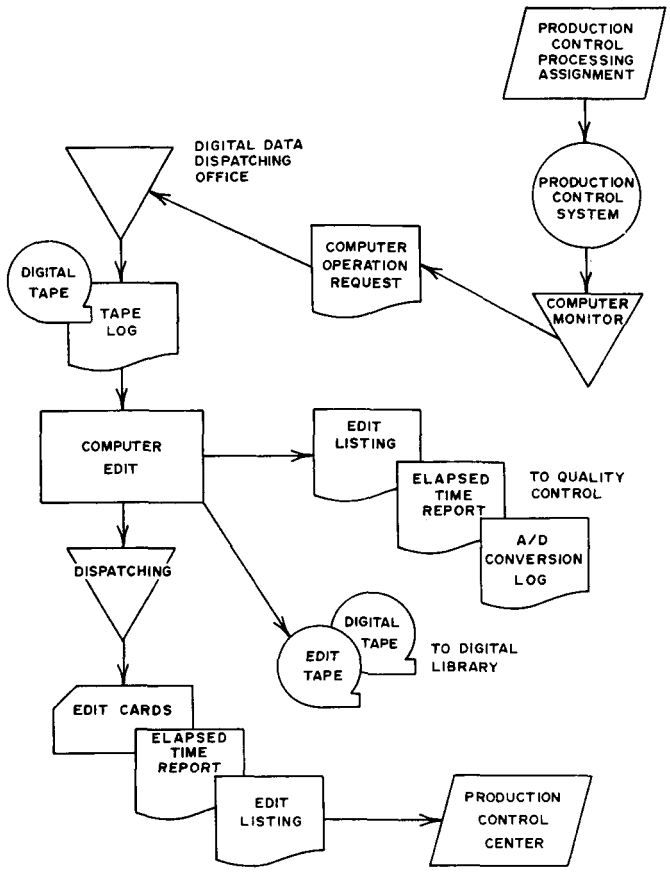

Figure 39. Digital Data Accounting Operations

1030 communication system. Decommutation data, normally added to the edit cards, can be inserted into disk storage from the 1031 input station in Production Control. This eliminates the last punch card step currently conducted by the Digital Data Accounting Office.

Accessible Records

The update of a master file tape will be eliminated in the system. In its place a record will be written of the entire disk master file for a weekly period. This difference is that the new magnetic tape records will be written with no sort or merge operations which normally consume long periods of time because of tape movement. All information in the accounting files represent current data about the tapes and can be called for at any time.

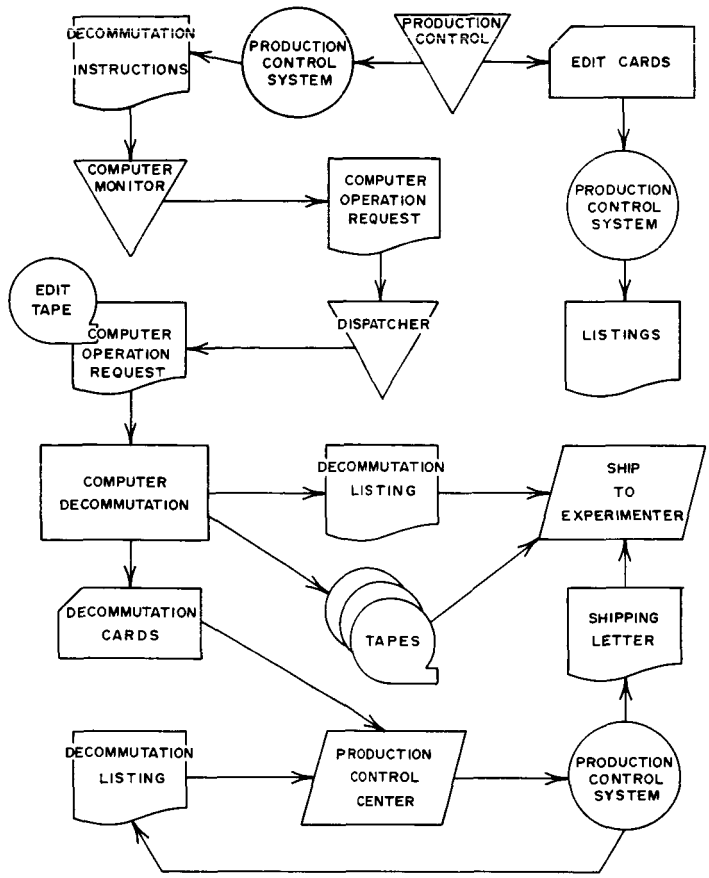

Figure 40. Digital Data Accounting Operations

Throughout the accumulation of accounting data, a summation of pertinent statistics will be compiled. This will include such items as the number of new files, files updated, tapes digitized, edited and decommutated, and tapes released for shipping. Weekly listings and outputs containing statistical summaries will be initiated by communicating over the 1030 collection system between Production Control and the IBM 1401 central processor. A summary record for weekly transactions will be written on magnetic tape at the end of each accounting period.

Advantages

This report has discussed the advantages of an automated production control and accounting system that will eliminate repetitive operations as well as large punch card libraries and suspense files. It illustrated that by utilizing a large random access storage unit, in this case, a disk storage drive, stored data would

be readily available for recall. Because of this, all listings and reports produced on different computers in the Data Processing Branch could be consolidated and printed out directly from the IBM 1401 which serves as the central processor for the Production Control and Accounting System. Finally, all the outputs used for either control or management purposes, as specified in the system specifications, are available by program reference without having to use data that must be extracted from punch cards or from magnetic tapes.

The proposed system configuration does not attempt to define what information should be placed in each file of accounting data. The report concerns itself with the manner of handling fields of data that are presently incorporated in the accounting system. The number of 320 total characters in a file includes 230 defined characters, 147 of which are in current use, in the master record of each file plus 90 more characters for expansion. These added characters are derived from a management estimate and can be adjusted appropriately to meet future accounting requirements. In the event this file length is considered to be inadequate and more characters are placed into a record file, then the disk storage will have to be increased by the ratio of the new amount of 320, the originally assigned length.

Emphasis on what the proposed system represents is important. The system is not intended to represent the ultimate solution for automating present accounting and control procedures. Until an assessment of how well the different operations can be improved, some steps such as initial generation of punch cards will remain part of the production process.

The major contribution of the system will be consolidation of control, of information storage and accounting to a central source.

SYSTEM ANALYSIS

SYSTEM REQUIREMENTS

The requirements specify the system be capable of maintaining an active account of fifteen satellites with an average of 150 files per satellite inserted into the system each week. The weekly input of new files to the system will therefore be 2,250 files. This is an average of 450 new files per day.

It is assumed that once the system has reached its projected storage capacity all files put into the system for a given week will have normally been completed eight weeks later. This implies a linear flow of data through the system under normal operations. The rate of average input for any time span can be determined by the number of entries of data fields divided by the number of input stations in the system.

There will be three main locations that will be responsible for inserting or changing accounting data in the system.

The stations are the analog data office, the analog to digital processing area and the production control center.

Data field changes are made (1) when the initial analog cards are punched, (2) when analog to digital conversion takes place (3) when digital tapes are edited and (4) when decommutation and final shipping takes place and (5) when tapes storage dates are inserted. For orderly processing to take place, 450 files must be moved through the system each day. For this operation to be continuous, where in theory the first file into the system will be the first file out, file entries will be made for 450 files at all five processing stages. The total file changes will be 2250 per day. This is an average hourly input rate of 256.5 entries.

MASTER RECORD FILES

The file length of 320 characters is a projection to include future field entries. It is recognized that the projected quantity is nearly 3 times the size of the present file which will be discussed. The expanded file configuration is used to estimate the future storage capacity when items, determined to be feasible, are included in the accounting data. The data that is included in the present file length is that which the Production Control Office uses to automate and regulate the current process. The files will be expanded when it is determined to be necessary, and in the best interests of the parties utilizing the data stored in the master file.

The present file length accommodates 28 accounting fields of 147 characters. Some of these fields are not being recorded since the present production system does not utilize them in its reports. Table 1 lists the fields comprising the 320 character file. The first 27 fields are used, or can be considered to be used because they were programmed for in the past and subject to reinsertion.

Table 1

CONTENTS OF MASTER RECORD

Field	No. Characters	Field	No. Characters
1. Satellite	4	17. Edit File	2
2. Station	3	18. Digitized Date	5
3. Analog Tape	5	19. Edit Tape	5
4. Analog Tape File	2	20. Decommutation Date	5
5. Analog Record Date	6	21. Shipping Date	5
Edit Record Date	6	22. Evaluation Date	5
6. Pass	4	23. Data Quality	2
7. International Code	7	24. Strip Chart Date	5
8. Analog or Digital Processing Status	1	25. Location of Analog Tape	5
9. Analog Start Time	6	26. Comments	20
10. Analog Stop Time	6	27. Analog Tape Storage Date	5
11. Edit Start	6	28. Experimenter Tape File 1	4
12. Edit Stop	6	29- Experimenter Tape	76
13. Date Analog Tape Received	5	47. File 2-20	(4 each)
14. Processor Tape Number	5	48. Run Number	3
15. Processing Line	2	51. Update Codes	3
16. Edit Tape	4	52. Future Contingencies	92
		Total Characters	320

DATA INPUTS

The method of inputting the data will vary from station to station. The initial entry of data can be accomplished solely by use of a card insert into a 1031 input station. The other processing steps can be made by use of either a card,

badge, manual insert or a combination of these. The methods of entry which are to follow may later be changed or modified to better meet a specific situation. The methods to be suggested are the considered opinion at this time. They will serve as a guideline for later system considerations that may arise and will aid in dictating improved input techniques. This input discussion refers solely to entries at the 1031 input stations.

DATA FIELDS

It is significant that a date must be added after each processing step. The date of initial entry, that is the date a tape is received, is punched on a card with the other analog data fields. Some satellites have an edit date punched on the edit card during the edit process but this is not always the case. In the other steps a date must be supplied.

The Production Control and Accounting System will be capable of supplying the date needed by having five characters representing a date field set into the 1401 CPU each day before processing activities commence. The locations containing the date field will be accessible to all program sub-routines requiring a current date and it can be extracted accordingly. Thus when entries are made for analog to digital conversion, editing, decommutation and shipping, and finally the tape storage date, the date field can be called up from its resident address and placed in the field assigned to the date for each of the processing steps.

IDENTIFICATION DATA

The 1031 input stations have 24 characters that can be manually inserted into the system at any one setup. When the station is used the following fields, not necessarily in the order assigned, can be used for entry into a file:

1. Satellite - 4 characters

2. Station - 3 characters

3. Analog Tape - 5 characters

4. Analog File Number - 2 characters

The above fields of identification data require fourteen character positions, so there are ten characters left for file data.

ENTRY CONSIDERATIONS

Sequence and transaction checks are part of the system controls.

The input stations, with the exception of the management station (Figure 28) assigned to production control should be confined to the performance of a specific type of transaction. A transaction will be checked to see if it was placed into the file at a proper time. For example, a station designated for edit functions would be able to transmit edit data and it would be allowed to transmit such data only after the file was checked for all prior sequences; in this case initial file entries and analog to digital conversion entries.

The following sequence must be followed or the operator at an input station will be notified that the transaction was not accepted:

1. Initial data entry
2. Analog to Digital conversion data entry
3. Edit Data Entry
4. Decommutation and shipping data entry
5. Storage data entry

The 1031 has the capability to operate with three inputs, one from the 80 column punch card, another from the 24 character manual slide insert and finally with a 10 character badge. If complete location checks are felt to be necessary, a combination of the three inputs will allow all characters used for location identification and verification to be included for input validity tests. This approach is time consuming at best and will increase the man-hour feeding time to the input stations considerably. Responsible operators who service the station will be able to eliminate the same errors that multiple input redundancy checks provide by careful scrutiny of the manual slide setup with the information sheet from which they obtain their data. In this way the manual input method will be sufficient and storage of ancillary cards and badges will not be necessary.

DATA ENTRY PROCEDURES

The following procedures are used for inserting data into the production control and accounting system from the 1031 input stations. These methods are a feasible approach and consider both the file check features and time expended in storing the data.

I. Initial Analog Data Entry

This initial entry consists of 11 fields of 50 characters. All the required fields are contained on an 80 column punched card which will be inserted to establish each analog file. Once a file has been placed onto the disk file its location will be set into a file directory. Subsequent additions to the file will be made by program reference to the directory. An initial file sequence test will be made to regulate the file ordering. The initial files should be entered from the IBM 1402 card reader if large batch processing is required, otherwise, a 1031 input station located at the Analog Data Accounting Office, should be used.

II. Analog to Digital Conversion Entry

Two fields of information are entered into the master file after analog to digital conversion. One is the buffer processing line number (2 characters) and the other is the date digitized (5 characters). The process for updating will be accomplished by using the manual input of a 1031 input station. A total of 16 characters are inserted into the input station. Identification data consisting of fourteen characters of satellite, station, analog tape and analog tape file will be inserted along with the two characters for the buffer processing line. When the data is keyed in the system will test the 14 identification characters against the file directory to see that a file has been established. It will place the two data characters in their proper field and extract the 5 character recorded date from its central processor location and store it in its proper field.

Note that a specific 1031 input station can be used to perform this transaction or the transaction can be keyed in by a character designator. A one character transaction code can be used rather than restricting the input station to one process function.

III. Edit Entry

The edit data is composed of 8 fields of 35 characters. All the data is generally contained on 80 column punched cards generated during a computer edit run. On a few satellite edit programs the edit date is not generated, leaving 7 fields of 30 characters. Entry into the system will be accomplished by placing the cards into the 1031 input stations. After a station transaction check is performed for the proper process sequence, the identification data on the card is checked against the master file and if all characters match, the data are placed in their proper fields. The date of edit field will be supplied, if needed, from the central processor. This can easily decided by satellite identification in a program sub-routine.

DECOMMUTATION AND SHIPPING DATA ENTRY

Although a decommutation card is generated during a computer decommutation run, the only new information introduced into the master file is the decommutation date. The card is used to generate a shipping letter of experimenter tapes which is to be sent to various users. The date the decommutated tapes are shipped out of the Data Processing Branch to the experimenters is within a short time after decommutation has been completed. For accounting purposes the tapes are considered shipped when they are removed from the Digital Data Accounting Office immediately after decommutation and are sent to the shipping department. The date for shipping is therefore placed into the master file at the same time as the decommutation date.

The manner of placing the date into the two fields will be done by inserting the decom card into a 1031 input station designated for this transaction. The date will be called for from the central processor once the transaction and file have been verified, and placed into the decommutation date and shipping date fields.

STORATE DATA ENTRY

The storage data is a calendar date field of five characters and it tells the date that an analog tape is stored after all processing has been completed on it.

This information will be sent to a five character field in a file on the disk storage from a manual input station in the Analog Data Accounting Office. A 1031 manual keying station is used to insert the data. The operator will set in a one character transaction code (this is done since no card will be used for this operation) and a 14 character identifier which will call out the routines to check and write the required date. The operation will consist of the 15 character setup and key-in to the system.

ADDITION COMMENT DATA ENTRY

A 20 character field for comments is included in each record of the master file. The field is reserved for use by the Production Control Office and data will be placed into it from the 1031 input station that is used as a management station. This transaction can be carried out at any time after the initial analog file is established but only from the management station. The method of entry will either be from punched card or by manual input and the message format can be coded designations to represent standardized comments, or simply comments in alpha-numeric form that is constrained to 20 characters.

SUMMARY OF INPUT OPERATIONS

Five processing steps have been accounted for in the system. The inputs for two steps are from punched cards fed into a 1031 input station. No other mode of input is needed since the necessary dates to be added are placed in a location in the central processor. The other three steps are accounted for by setting up manual slides on 1031 input stations and keying in transaction, identification and file data.

Punched cards are held only for the period of scheduling, normally weekly, calling for storage of the contents of the master file on the disk storage to digital magnetic tape records.

The comment data entry is additional and may not be used frequently. Information inserted in the comments field is extraneous to the processing steps and can be inserted randomly from the Production Control Center by either punched cards or manual entry.

DATA OUTPUTS

The outputs from the Production Control and Accounting System will be in the form of printed material or magnetic tape recordings. The data output will consist of data contained in the master file or statistical summaries and computations concerning the data.

A listing of possible outputs is as follows:

1. Total master file of 5,760,000 characters
    a. Weekly magnetic tape storage file
    b. Unscheduled printout of master file
2. Printout of total files of any one of fifteen satellites
3. Printout of one 320 character file from any satellite
4. Printout of selected field or fields from any satellite
5. Summary Data
    a. Total number of files in account
    b. Total files added per specified period

c. Totals of types of transactions performed

d. Files upon which transactions took place

e. Active files

f. Completed and inactive files

g. File inventory

h. Output of all summary data to magnetic tape

6. Messages

a. Production Control/Analog Data Accounting

b. Production Control/IBM 1401 Operations

c. Production Control/Computer Monitor

The outputs listed will be printed out on the IBM 1033 output stations of the system for the most part. Outputs of great quantities of data such as items (1) and (2) will be printed on an IBM 1402 printer. The data written on magnetic tape (items 1.a. and 5.h.) are taken periodically from the disk file and placed on the other medium to insure that a redundant record source is available for checking and emergency purposes. These tapes should be retained only for a useful life cycle.

All outputs other than those calling for printouts on the IBM 1402 printer or the recordings on the IBM 729 tape recorders will be done under message control from the Production Control Office management station. A designated transaction code will be entered on the manual keyboard of a 1031 and the data will be extracted from the accounting files or the summary data files and printed out on a 1033 output print station. These output operations can be performed at any time without any noticeable interference to other activities taking place at the same time.

TIMING CONSIDERATIONS

Table 2 lists the areas in which timing conditions have to be taken into account. The role equipment operators play in servicing the system is of importance for production scheduling. The actual transmission time of the data through the 1030 communications system and the time absorbed by central processor operation will be minimal yet will influence the method of 1031 scheduling since queuing can be a factor.

The times given for the various phases of human and equipment performance are approximations. The 1030 input station setup figures are empirical estimates whereas the values stated for standard equipment times are based on figures expressed in the manuals for individual operations. Both single and total processing step times are given in the table. The totals should not be construed to mean all operations consume the time during one interval. The totals include both random or scheduled time increments and can represent an accumulation of time used over many servicing operations.

Table 2

TIMING CONSIDERATIONS

I. 1030 Data Collection System Timing
   - A. 1031 input stations
     1. Human Factors-Setup Time
        - a. Card Input
          - (1) Single input - 5 seconds
          - (2) Total Process of 450 inputs - 37 minutes 30 seconds
        - b. Card Input
          - (1) Single Input - 30 seconds (24 characters)
          - (2) Total Process of 450 inputs - 3 hrs 45 minutes
        - c. Badge Input
          - (1) Single Input - 3 seconds
          - (2) Total Process of 450 inputs - 22 minutes 30 seconds
   - B. 1033 Output Print Station
     1. Character printout time - 67.7 milliseconds
     2. Print line rate (130 characters) - 8.8 seconds
     3. 320 character File - approximately 21.6 seconds

Table 2. Timing Considerations (Continued)

II. 1030 Internal Transfer Rates
  A. Character transmission
    1. Character transmission time - .0167 seconds (60 per second)
    2. 320 character file transmission time - 5.33 seconds
  B. Data Transfer Times From 1026 Controller to CPU
    1. Maximum read/write time - apprx 5 m.s.
    2. 450 transactions - 2.3 seconds
    3. Total Daily transactions (2250) - 11.5 seconds

III. Disk Storage Drive
  A. Access time - with Direct Seek & Seek Overlap Features
    1. Average access time - 150 milliseconds
    2. Minimum seek time - 54 milliseconds
    3. Maximum seek time - 250 milliseconds
    4. Random process step of 450 records - 67.5 seconds
    5. Total Disk references for 2250 records - 5 minutes 38 seconds
  B. Rotation Waiting Time
    1. Average - 22 milliseconds
    2. Minimum - 2 milliseconds
    3. Maximum - 42 milliseconds
  C. Data Transfer Time
    1. Read, write or check - 2 milliseconds per sector
    2. (Transfer is by sector)
    3. 4 Sector (320 characters) 8 milliseconds

IV. 1402 Card Reader
  A. Reading Rates
    1. 80 column cards - 800 per minute

V. 1403 High Speed Printer
  A. Print Rate
    1. 130 character line - 600/minute
    2. Spacing
      a. 1st line - 20 m.s.
      b. 2nd-8th line - 5 m.s.
      c. 9th-Nth line - 2.3 m.s.

PRODUCTION CONTROL AND ACCOUNTING SYSTEM ENTRY TIMES

The values presented in Table 1 can be used to arrive at the approximate times used for each input of a process step and for the total time required for all inputs performed during one of the five steps.

1. Initial Entry

A. IBM 1402 Card Reader

An IBM 1402 card reader is recommended for batch processing of the initial entry of analog cards. The reading rate of the 1402 is 800 cards per minute, discounting central processor storage time, so a loading cycle of 450 cards takes 33.75 seconds.

B. 1311 Disk Storage Drive

The 450 cards must be separated for files on 15 satellites. This means that 15 access times are necessary for each batch of initial entry cards. The average random seek time with a direct seek modification installed, is 150 milliseconds, so 2.25 seconds will be used. The rotation waiting time will be 9.9 seconds for 450 average rotations waiting periods. Each 320 character file transfer consumes 8 milliseconds so the total transfer time will be 3.6 seconds for 450 entries. The total time for all three of the disk storage drive functions is 15.75 seconds. This time does not include the internal program times necessary to input and store the data, to develop summary information, and to merge and setup accounting directories. The time consumed will be negligible in these and other processes compared to the above transfer and storage figures.

C. Operations Times

The timing calculated assumes all cards are entered in the 1402 at one time. If the entries are made at different intervals then the disk seek and rotation times must be added for each batch entry. Also, even though the entries are ordered by satellites, there is no guarantee that files will be sequential within a selected cylinder on the disk storage. This is why the total rotation time has been summed for all 450 entries.

Initial Entry

The totals required for daily initial entry include the times used by the 1402 card reader and the 1311 disk file. These times were given as 33.75 seconds and 15.75 seconds in Table 1, for a total of 49.5 seconds. Central Processor program time should not be significant since the routine is basically a block storage and housekeeping function. The servicing program will reside in the central processor for easy reference. Therefore with a basic machine cycle time of 11.5 μsec to be considered, it is estimated that this redundant loading program should not consume any more than 10 seconds. With these figures, the total initial entry time required is 59.5 seconds. This does not imply that the

CPU must be locked out from other tasks while the operations of loading are being carried out. This is also true for the other terminal entries, and lockouts will be determined by priorities and program expediencies.

ANALOG TO DIGITAL CONVERSION DATA ENTRY TIMES

The time used to insert analog to digital (A/D) conversion data into the system from a 1031 input station is made up of the operator time for manual input, transmission times between input stations and the 1026 controller, data transfer from the controller to the 1401 CPU, and the associated disk storage time.

The total manual keying time for 450 random, or sequential, entries is 3 hours and 45 minutes. This time, taken from Table 1, is independent of any machine time used for the entries but must be considered for personnel work-load factors, i.e., total operator man-hours, for estimating effective use of the system.

The total system time consist of the following equipment increments:

a. 1031 input of 450 entries of 16 characters (five date characters added by the CPU are not included) to the 1026 transmission control unit takes 120 seconds at the stated rate of 60 characters per second.

b. The transfer rate between the 1026 controller and the CPU is determined by timing equations furnished by the manufacturer. CPU memory cycle time and the number of characters to be transferred are the variables in the formula. There is a fractional variation between reading and writing calculations that need not be considered for purposes of this report. An additional character increases the time by .020 milliseconds. Entry time for the 16 characters in this operation takes approximately 5 milliseconds. For 450 entries, the required 1026 to CPU time is 2.3 seconds.

c. Disk Storage time is divided into seek time, rotation waiting time and data transfer time. As in the initial entry it is assumed that there is ordering by satellites so the loading time includes all timing for 15 different satellite references for the 450 entries. If the 450 cards are inserted in blocks at various times of the day, for example morning, noon and late afternoon, then the disk times will be added each time. Since the realistic approach to servicing this 1030 station will be to divide the entries into several loading periods because of human engineering factors, three entry times with 150 entries for each will be considered to illustrate the timing considerations. The disk storage time needed will be the individual increments of 2.25 seconds for 15 disk seeks, 3.3 seconds

for 150 average rotation times and 0.3 seconds for the data transfer rate into 150 different sectors. Each cycle of 150 entries will consume 5.85 seconds. Total entry time for three 150 entry cycles will be 17.55 seconds. If all entries were made at one setup the total entry time would be 13.1 seconds since two seek times are eliminated. (The difference is the reduction of the previous total by 4.5 seconds used for 2 seek operations.) This time is trivial for this operation and the loading should be scheduled for operator convenience because of the extended servicing time stated.

Total machine time associated with the loading of analog to digital conversion data entry from the 1031 input station to disk storage is approximately 140 seconds.

Note that no estimate of internal timing of the directory and summary subroutines are accounted for at this time. The time added by them can be minimized by thoughtful programming techniques and the figure added should be negligible compared to the machine timing requirements that have been listed. Examples of critical areas of the sub-routines are discussed in the final section on programming aspects.

EDIT DATA ENTRY TIMES

The edit data is to be placed into storage by inserting a punched card into a 1031 input station. Thirty, or thirty-five characters, depending on whether or not a calendar date of five characters is included, will be transmitted. Fourteen characters will be used for identification and the remaining sixteen characters will be transferred by the CPU into disk storage. The machine time used for the operation will be consumed by the transfer of data from the 1031 input station to the 1026 communication controller, by transfer of that data from the 1026 to the 1401 CPU and from the 1401 onto disk storage. The 1031 to 1026 transfer time for 450 entries of 30 characters each will take 225 seconds. The movement of data into the CPU is governed by the 1026 and will take 2.3 seconds for 450 entries of 30 characters. The disk storage time will be dependent on the amount of entries made at any given input cycle. For 150 entries, the time used will be 2.25 seconds for accessing, 3.3 seconds for rotation of the disk to a sector and .3 seconds to write into 150 sectors. Thus the time will be the same as the previous operation when summed to 5.85 seconds for 150 entries and total 17.5 seconds for three input cycles. Likewise if all 450 entries were made at one time 13.1 seconds would be used.

The total system time used will be 241.7 seconds if all entries are made at once, and 81.62 seconds for each input of 150 entries at a time. The total for the method will be a slightly larger time of 244.85 seconds since the disk must be accessed more.

Random inserts require a new disk access time and a different rotation time must be calculated. Random entries made throughout the work day will not impair systems operation so any queuing of stations will be unnoticed by the operators servicing them.

The manual keying time needed to perform the insertion of cards into the 1031 input station is not extreme and can be done in about approximately 37 minutes and 30 seconds. This estimated value is stated in Table 1. It is based on 450 entries, each requiring 5 seconds of service time. The matter of partial or total blocks, or random entries, has no bearing on the total time calculated since service time is based on a per unit entry.

DECOMMUTATION AND SHIPPING DATA ENTRY TIMES

The entries at this step are made through a 1031 input station. Punched cards are also used for these entries, and they supply identification information which the CPU interprets, validates and afterwards calls up a pre-stored calendar date in the CPU which it transfers into the fields of a selected file denoting Decommutation and Shipping Data. The timing considerations for manual servicing are the same as the previous operation and take approximately 37 minutes and 30 seconds.

The system load and store time is the total time used to place 14 identification characters into the CPU for a file comparison and to transfer a five character date into 2 fields. The 1031 to 1026 transfer time will be 105 seconds for 450 entries of 14 characters. The 1026 to CPU transfer time will take approximately 2.3 seconds (Table 1) and the Disk Storage time will take 17.55 seconds (three input cycles of 150 entries is again considered as an acceptable loading cycle) for a total time of 125 seconds.

Two points are stressed here:

1. The CPU is not locked out from other input/output or processing operations while this operation takes place.

2. The data transfer times are not calculated precisely for the 1026 to CPU transfer because the added transfer time is negligible for the characters being placed into the system for the operation. This also holds for the CPU to the Disk storage where transfers are performed by moving sectors in and out of storage rather than operating on a character by character basis.

STORAGE DATA ENTRY

This information is placed into the system by the Analog Data Accounting Library after all processing is completed and an analog tape is placed in a magnetic tape archive.

Identification data of 14 characters is set up on the keyboard of the 1031 input station for manual entry. This information is diagnosed by the CPU which verifies the station, file and entry sequence and extracts the prestored date from a holding location in the CPU and stores it on the disk file. This operation like the others can be scheduled in the most appropriate manner. Since the total operator servicing time takes 3 hours and 45 minutes for 450 manual inputs, a staggered entry arrangement is most desirable from a operations usage point of view. Timing will be comparable to the other inputs, so if 450 inputs were made then about 125 seconds would be required.

RANDOM DISK STORAGE

The loading of the disk in a random manner is not prohibitive in the production control and accounting system. This method has not been stressed as a desirable one because of difficulty in maintaining a balanced work load for personnel servicing the 1030 data collection system, and also it impedes uniformity in scheduling operations. As mentioned earlier, the added time caused by random loading of the entries from the different input stations will not materially alter the systems' operations concept. The critical timing for any single entry is in accessing the disk storage. Each average access time is 150 milliseconds, so if each file entry during the day were made on a random basis a total of 5 minutes and 37.5 seconds would be used establishing the mechanical heads of disk in order to write data.

All individual operation times of the disk are multiplied by the estimated total of 2250 entries per day. The previous seek time was arrived at by multiplying 150 m.s. by 2250 entries. Rotation time must be calculated in the same way so its total is 22 ms times 2250, or 49.5 seconds. The sector transfer time is likewise calculated for 2250 entries at an average of 2 ms/entry for a total of 4.5 seconds. Total disk storage time is 6 minutes 31.5 seconds.

The time taken for transmission of data from the 1031 input station to the 1026 transmission control unit is the total amount of characters inserted through the 1031 times 1800 entries from four operational elements. The 1031 is used on a normal scheduled basis for entries for A/D conversion data, edit data, decommutation and shipping data and storage data. Initial data entries are made by card reader directly into the CPU. They would not normally be handled on a

random basis because of the nature of the accounting methods. For this reason the initial entry time is considered as a one time operation. It is not prudent to perform the initial entry randomly because of the setup requirement for each new file. A departure is made for this operation and its time is added to the other operation entry times in its entirety. The additional time is that calculated for the 1402 card reader loading time of 33.75 seconds. They will be negligible in any case and will not materially change the calculations. A/D conversion data has 16 characters, edit data consists of 30 characters, decommutation and shipping has 14, as has the storage data.

The 1031 transfer times have been given in the separate sections for these operations. They are used herein and their total is 564 seconds or 9 minutes and 24 seconds. With all times tabulated the system is only taxed for 17 minutes and 29 seconds to perform all the current input requirements for production control and accounting. This value will be increased by priority scheduling and lockouts contributed for program interrupts to perform different tasks, but the added time will not be significant except in the case where a slow output medium is used for an extended period of time.

OUTPUT TIMING

Output times can be calculated in terms of the work being performed. In general, three outputs need to be considered:

1. Large printout tasks on the 1403 printer
    a. Station to Station Listings
    b. Analog to Digital Chronological Listing
2. Small printout tasks on the 1033 output station
    a. Station to Station Listings
    b. Analog to Digital Chronological Listings
    c. Summary Reports
    d. File Printout
3. Magnetic Tape recordings
    a. Master File

3. Magnetic Tape Recordings

   a. Master File

   b. Summary File

DISK TRANSFER CHARACTERISTICS

The quantity of characters of data that are read for output from the 1311 disk pack have a bearing on the timing. A disk pack is organized sectionally as follows:

1. The basic unit comprise a sector of 100 characters

2. Twenty sectors (2,000 characters) comprise a disk track

3. Ten tracks form a cylinder (20,000 characters)

4. One Hundred Cylinders comprise one pack (2,000,000 characters)

5. The Production Control System contains 3 packs (6,000,000 characters)

The disk access time, used for seeking a record, must be considered when a change from one disk cylinder to another takes place. As an example, when the master file stored on the disk is to be recorded on magnetic tape, 5,760,000 characters (the amount required under this system's specifications) must be transferred. Assuming a sequentially ordered storage facility, an output routine would have to call for the disk access mechanism to be positioned 288 times.

The initial reference can be to any position and can be either the minimum or maximum movement. For purposes of critical timing for a single case, the maximum seek time of 150 milliseconds is taken. Thereafter, a read operation encompassing such a large quantity of data will be sequential, the average seek time will be 54 milliseconds. This access time is achieved through the addition of the Direct Seek and Seek Overlap features to the system. The total seek time will be the 150 milliseconds and 287 seeks times 54 milliseconds, or 15.498 seconds, for a total of 15.65 seconds.

EXAMPLES OF ESTIMATED OUTPUT TIMES

The following examples discuss the times estimated for different outputs on the 1403 printer, the 1033 output station printer and the magnetic tape.

1. Printout of Entire Master File

This output will take place on the IBM 1403 high speed printer which can print 130 character lines at 600 lines per minute. The master production control and accounting file is comprised of eighteen thousand, 320 character records. If all 320 characters were printed then an evenly apportioned printout format would consist of four 80 character lines for each individual satellite record. For visual convenience a space would separate each record. A total of 72,000 lines would be needed to print the 5,760,000 accounting data characters and spacing would be required 18,000 times. A printed line takes 100 milliseconds and the skipping of every fourth line consumes 20 milliseconds. Thus the time required to output the master file will be 120 minutes for printing and 6 minutes for skipping which is a total reproduction time of 2 hours and 6 minutes.

The printout operations are buffered so movement of data from the disk file to the CPU can be carried on while printing takes place. The 80 characters to be printed will be placed in an output buffer and the CPU will be free for processing 98 milliseconds out of the 100 milliseconds print cycle.

The timing for movement of the data from disk storage depends on the sequencing and amount of data read each time the disk is referenced. In this particular example data is removed from the disk four sectors of 100 characters at a time because movement in and out of the disk must be done by sectors consisting of that many characters. Over the course of an output, 57,600 sectors will be read out from 288 cylinders of disk storage. Access time is determined by cylinder references therefore a total cylinder access time of 15.65 seconds will be needed for sequential readouts. Another 14,250 rotation times for reference of each 4 sector block require 314 seconds and the transfer time of data from all the sectors takes up 115 seconds. This total rounded off, amounts to a disk utilization time of 445 seconds, or 7 minutes and 25 seconds. This time is interlaced between outputs to the 1403 print buffer and does not interfere with the buffer operation.

The only time movement of data in the production control system will conflict with an output will be when writing information onto, or reading information from the disk drive is performed. Random accessing of the disk during a large volume output will interrupt the output process, i.e., delay it because of the necessity of relocation the access heads of the disk drive and will penalize the system an average 150 milliseconds during each fetching operation. For this system where sequential sector addressing will be programmed, there will be no such conflict. Accessing is required whenever a change of cylinders occur so the access mechanism will only be moved 288 times and the access time will be the 16.75 seconds mentioned previously.

MAGNETIC TAPE STORAGE OF THE MASTER FILE

Data can be written on the IBM 729 Mod IV magnetic tape recorders at 200 or 556 bits per inch at tape speed of 112.5 inches per second. At this speed 22,500 or 62,500 characters per second can be written onto magnetic tape. Thus at 200 bpi a character is written every 44.5 ms and at 556 bpi, a character is written in 16 ms.

When data is written on magnetic tape the central processor is limited from performing other tasks during all but 3.8 milliseconds of a write cycle. If interrupts from other peripheral devices are expected and no noticeable queuing is a desired criterion of system performance, then records should not be of great length.

The recording speed of a tape unit, the number of records, and the record length must be considered jointly when preparing to write a large quantity of information such as the master accounting file of the production control system. This is required to determine the tape usage in feet as well as the time needed to perform the write operation.

The master file of 5,760,000 characters, for example, cannot be written on one tape at the 200 bpi packing density. The data alone requires 28,800 inches, or 2400 feet of magnetic tape surface. This leaves but 100 usable feet of tape for inter-record gape which take up 3/4 inch for each start and stop of the tape drive. With this restrict ion only 135 records could be written. To write the master file upon magnetic tape in 135 records would require 42,667 characters per record. This amount is impossible for the system to handle because of the CPU core storage which has only a 16,000 address capacity.

The logical course is to record data at 556 bpi. The tape footage required for the master file data will be 864 feet. This amount of tape will be used for data storage regardless of the file length.

If the data were removed from the disk storage on a file-by-file basis and recorded in the same manner then 18,000 files would have to be placed on a tape and the inter-record gaps would consume 13,500 inches or 1,125 feet of tape. This would hardly be considered sufficient with only 43.5% of the magnetic tape used for recorded data. Along with this, the tape drive, which must start and stop on each CPU output because it's writing operation is so much faster than the retrieval speed of the disk, will use 7.8 m.s. extra for each record being written.

A trade-off must take place between elements of the system and the final determination will be resolved between program and task considerations. If the CPU is used solely for output to the magnetic tape when this weekly master file storage task is done, then a large portion of its memory can be used as a transfer buffer between the disk storage and magnetic tape. Thus data for example could be transferred in large blocks of 12,800 characters or 6,400 characters. Since the storage has 16,000 character locations this approach would almost certainly require the temporary storage of all executive routines and statistical data in order to free the memory. The block lengths mentioned would be recorded in 450 and 900 records, and reduce the tape used for record marks to total footage, 28 feet or 56 feet; which gives excellent tape usage percentages of 97% and 94% respectively.

A reasonable compromise between the various timing and storage factors would be to use a block length of 3200 characters for each tape record. This consists of 10 files of disk data. The total number of tape records would be 1800 and would use 112.5 ft for the record marks. The recorded data would encompass 89% of the tape used and represents a merit figure that can be considered reasonable for any magnetic tape usage.

Another advantage accrues with the parameters selected. The tape can be used for storage of the master production control and accounting file on two occasions. Total tape usage for this will be 1,953 feet. Over 500 feet of usable tape remain and this footage can be utilized by writing all the summary data accompanying the master file as a separate record. The time and space required for this data is small compared to the figures presented for the master file.

The times involved in a magnetic tape recording consist of (1) reading 10 files of disk data 1,800 times from the disk to the 1401 CPU memory. In the sequential operation this will take the following calculated values for each transfer to memory: The transfer will consist of 32 sectors at a time. There will be 2 access references, an initial one which at maximum will take 250 ms and one sequential access of 54 milliseconds, both totaling 304 ms. Rotation is sequential and will require only that time for the disk to pass under the read/write heads for each block output. This requires 22 ms, so for 1800 references 39.6 seconds are consumed. The data transfer rate will be 8 ms each time a file is read. This figure is based on the fact that 320 characters must be stored in four sectors and each sector takes 2 ms to be transferred. Each block of 32 sectors consumes 64 ms of time so 1800 transfers will take 115.2 seconds. The total transfer time from the disk into the CPU for the entire master file takes 155 seconds.

The tape time associated with the output will be the time used by the magnetic tape unit in starting and stopping; i.e., 7.8 ms for each of 1800 write operations, which amounts 14 seconds; and the total number of characters; i.e., 5,760,000 at the character write rate of 16 ms for 556 bpi speed. This time amounts to 92 seconds. The total time required for actual writing is 106 seconds.

The system time expended for the operation of writing the master file on magnetic tape takes 261 seconds, or 4 minutes and 21 seconds.

FILE OUTPUTS FROM A 1033 OUTPUT PRINT STATION

The 1033 will print a character in 67.7 milliseconds, or at a rate of 14.8 characters per second. The station can be conveniently used for the printout of small amounts of production control and accounting data, and for message communication. A representative example output would be the printout of all the files of a particular satellite whose processing was completed during the accounting day. At the process rate of the system where 450 new entries are made, and 450 entries are completed, each satellite will have a throughput of 30 files.

Each file contains 320 characters so the 1033 print station would be printing 9600 characters. The total print time would be 649 seconds or 10 minutes and 49 seconds. Line spacing time is not defined, but considering it to be no faster than a character printout, and considering the 80 characters per line printout as specified in the 1403 printout example as a normal format, another 40 character times amounting to 2.7 seconds would need to be added. The total printer time would be 10 minutes and 51.7 seconds.

The disk storage transfer time would be calculated for 10 files, most probably sequential and at the worst, split between two cylinders of disk storage. The times used would be 300 milliseconds for access time. 66 milliseconds for the rotation time needed for the sector addressing of the 10 files in blocks of four, four and two sectors, and 20 milliseconds for the transfer of the data. The disk associated time is 386 milliseconds and the total system output time for the information is no more than 10 minutes, 52.2 seconds. However since the data is placed in the 1401 CPU and then moved out through the 1026 transmission unit to the 1033 print station, the output can be priority interrupted. Queuing time will be charged only on a line basis, so any input station in the communication system would only have to wait for 5.4 seconds to gain entrance. If no interrupts occur, a file will be printed in 21.6 seconds.

The latter figure for a file printout is perhaps a more important figure since it is likely that most callouts for file data will be done one or two files at a time rather than 30 at a time, as the example illustrates.

OUTPUT SUMMARY

The examples given should not be construed as actual tasks to be scheduled for production control reports. The transfer of data from the disk storage to magnetic tape in all probability, will be desired as record protection for a history of past performance. The complete master file dump on the high speed printer will rarely ever occur, and the printout of 30 files of data can be more conveniently handled on the high speed buffered printer. The examples do illustrate, even for extremes, how little time is demanded to perform these tasks and they lend evidence to the fact that the system restrictions are not imposed on any count by the 1401 central processor.

PROGRAM ASPECTS

The programs for the production control and accounting system will be incorporated in an overall executive program. The particular programs run on the IBM 1401 CPU can be reached through a 1401 program monitor (Figure 41). The monitor activates the 1030 communication systems service routines, compilation routines, and related and unrelated production work. The 1030 service routines are divided into directory organization for file location, creation of new records in the master file, production control and accounting file updating, file summary and message programs.

The compilation routines include the Fortran program language compiler, the 1401 Autocoder Assembler program and an input/output control system program for the 1026 transmission control unit.

The production work consists of all outputs assigned to the 1401 peripheral devices, such as summary reports and listings on the 1403 high speed printer, recording of the contents of the master file onto magnetic tape, and data processing runs that are devised for use for production control. Unrelated work will consist of any type of processing task that can be run on the machine without taking away needed storage space or causing excessive waiting time to the primary functions for which the system is to be used.

PRODUCTION CONTROL AND ACCOUNTING FILE ENTRY PROGRAMS

The programming requirements for the five date entry functions performed during a processing cycles are similar. The methods of entering data, the content and the number of fields inserted vary but the method of recognition and storage, and of maintaining statistical data will be identical in most cases.

INITIAL ANALOG DATA ENTRY PROGRAM

Initial entry of analog data (Figure 42) can be executed by entering punched cards in batches from a 1402 card reader or randomly from a 1031 input stations. The cards should be ordered by satellite to avoid excessive disk storage access time to accumulate. The initial analog data on each card read into the 1401 CPU will be looked at for required identification data by an initial entry check. If the entry is made from a properly designated input, and contains a proper identification coding, a test will be made to see if a file has previously been setup for the entry. If not a file location assignment will be added to the master file directory. The initial analog data of the entry will then be established in the master accounting data file in the 1311 disk storage. As each new file is entered a file count summary will be made on a daily, and if desired, a weekly

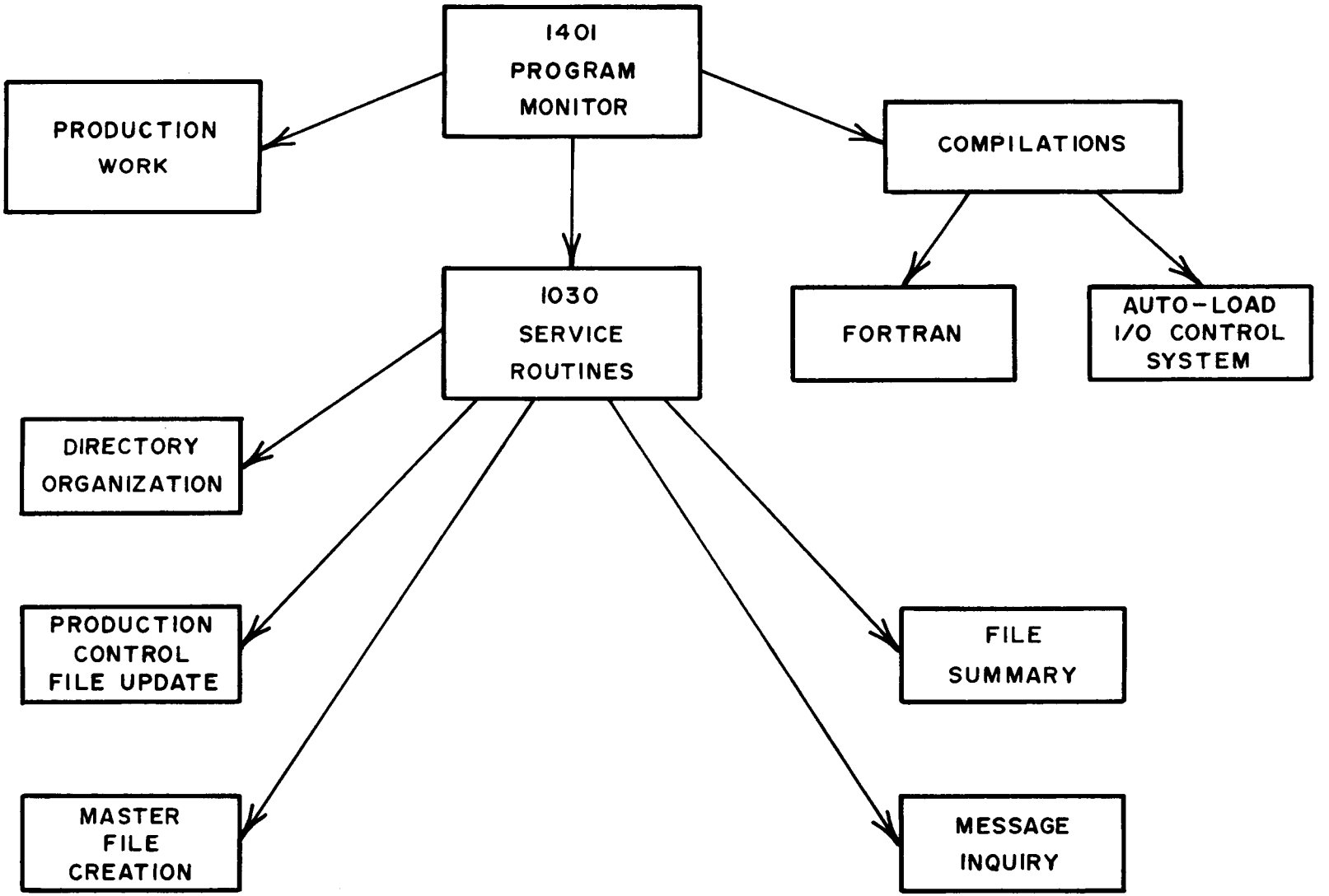

Figure 41. Production Control System Program Structure

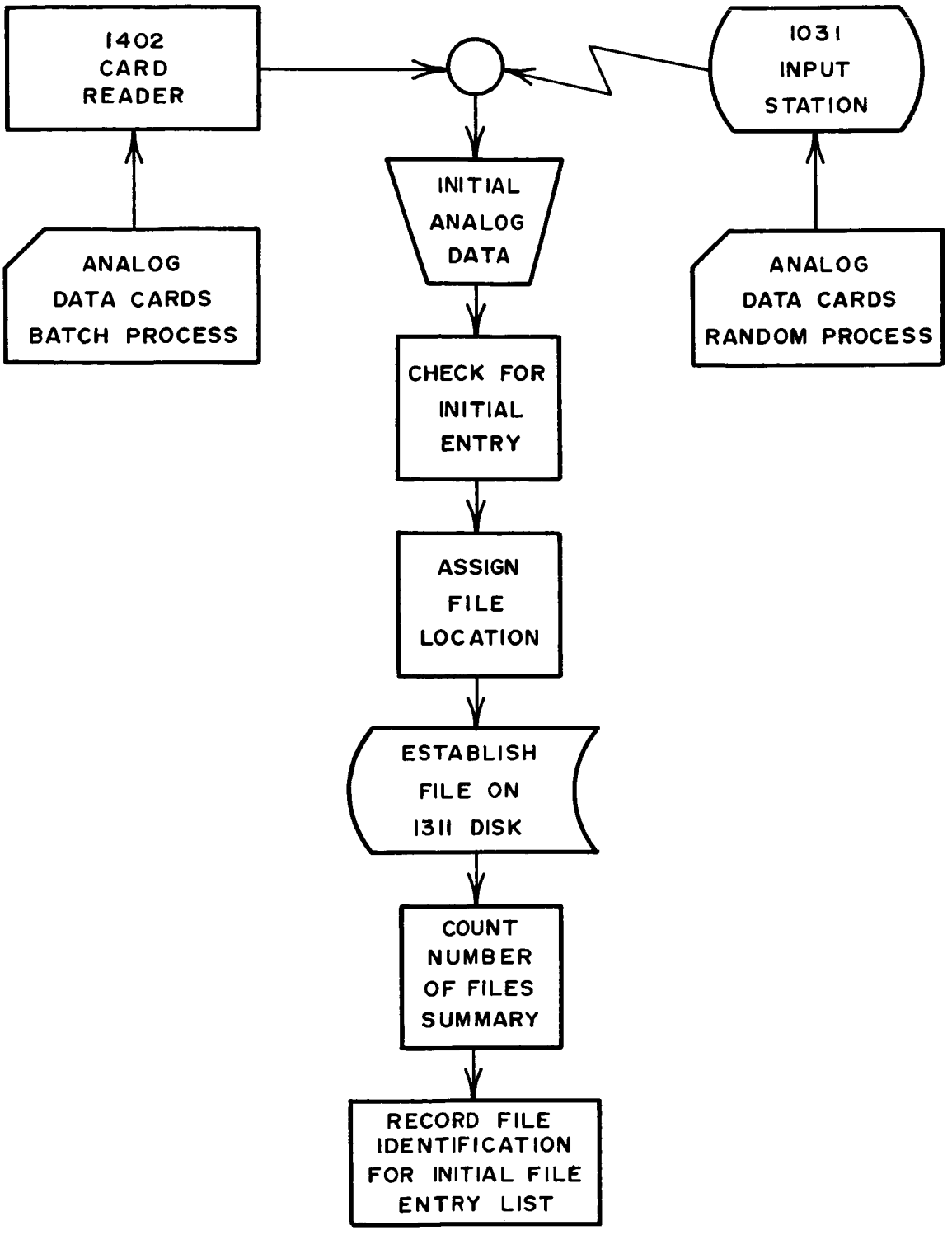

Figure 42. Initial Analog Data Entry Program Flow Diagram

basis. An entry list will be updated for each new input in order to identify which files are entered into the system on the current processing day.

ANALOG TO DIGITAL CONVERSION DATA ENTRY

Analog to digital conversion data (Figure 43) is manually keyed into the system from a 1031 input station. Before any storage into the master file is made, an input station test is conducted to certify that entry is being made from a designated point. A satellite file check is performed to see if a location has been established in the master file directory and if the identifying data is correct. Afterwards a sequence test is performed to make certain that the entry is occurring at the proper processing step. The CPU call ups of the current date and other required data are stored on the 1311 disk. The number of analog to digital file updates are counted, increasing with each entry, and a file identification is recorded for an analog to digital file entry list.

EDIT ENTRY PROGRAM

The programming flow diagram for edit entry is shown in Figure 44. The procedure is the same as the previous one, the only difference being in the method of input into the system. Edit entry is accomplished by card inserts into a 1031 input station. The edit data is subjected the to input station test, a satellite file check and a sequence test.

The current date is called and then all the edit data to be stored is written onto the 1311 disk. A count update of edit entries is performed and a record of file identification is made to complete the sub-routine requirements.

DECOMMUTATION & SHIPPING DATA ENTRY PROGRAM

Entry into the system for this step is done by punched decommutation cards (Figure 45). The program flow is the same as the edit sub-routine. Within the program itself, the current date called up is placed into two fields instead of one. The fields record the data decommutation has been completed and the date when the experimenter tapes are sent to the shipping facilities for distribution.

The usual checks and summary routines are included in the program.

STORAGE DATA ENTRY PROGRAM

Storage Date Inputs (Figure 46) are entered by using the manual keying mechanism of the 1031 input station. The input station test, and identification

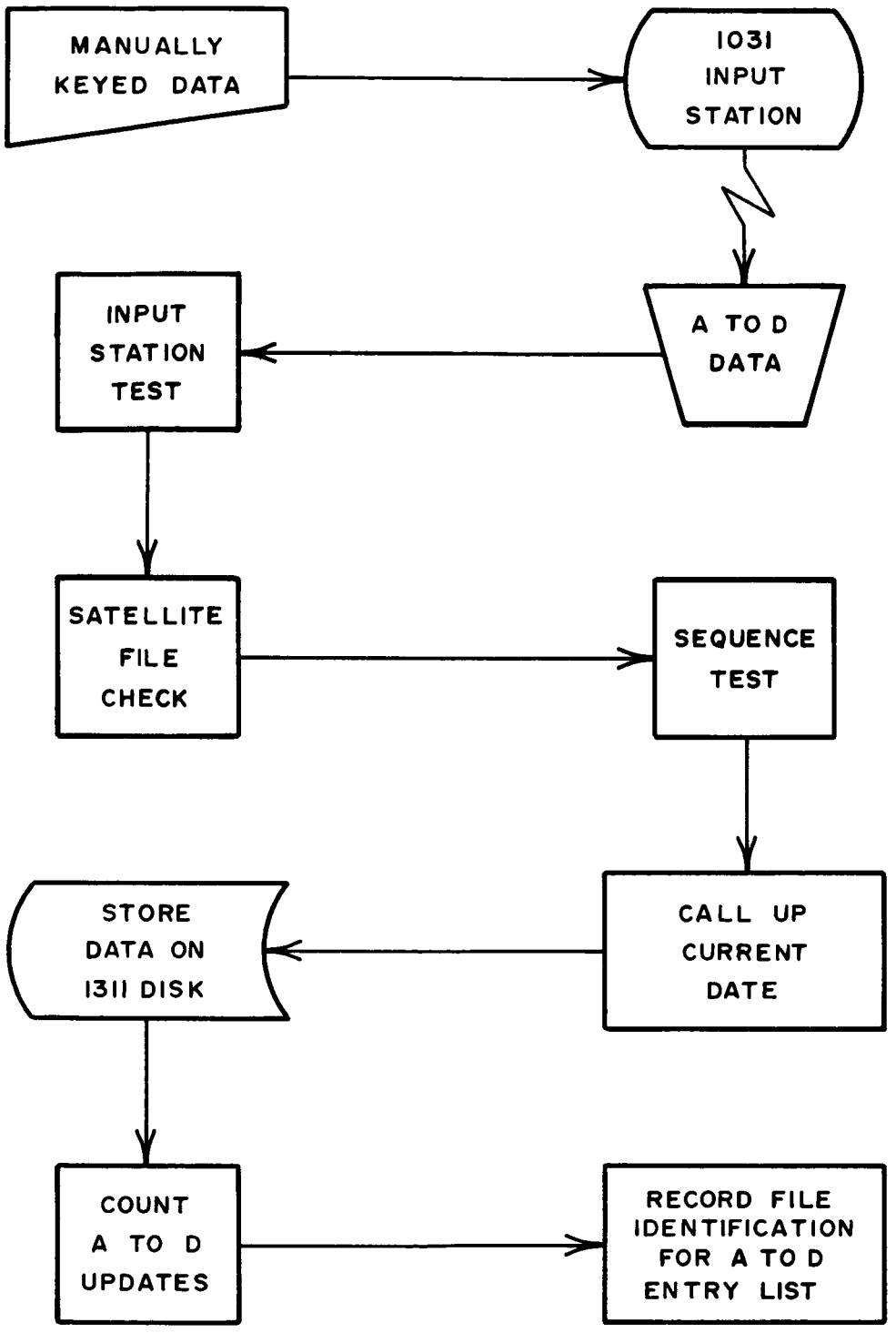

Figure 43. Analog to Digital Conversion Data Entry Program Flow Diagram

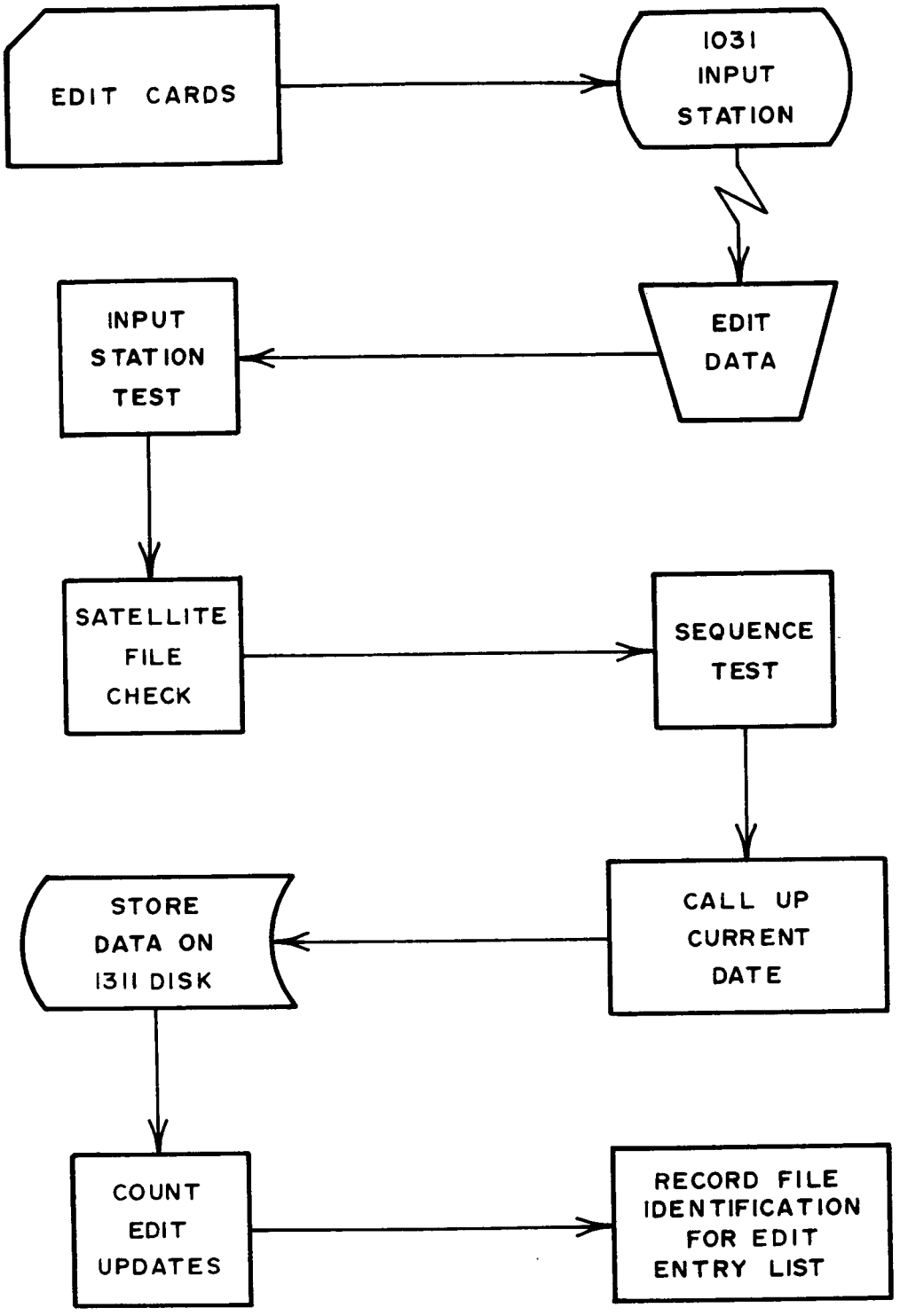

Figure 44. Edit Entry Program Flow Diagram

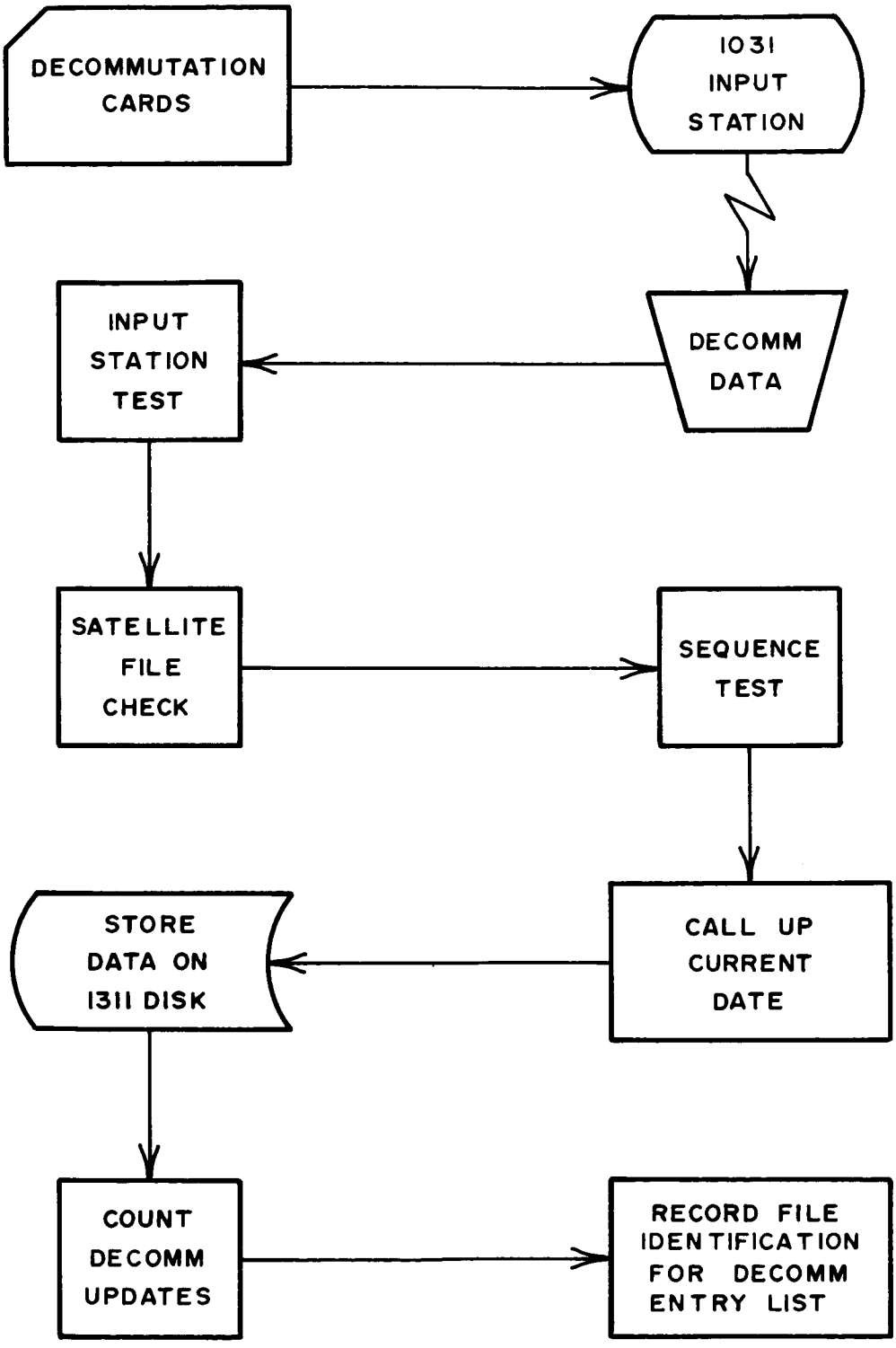

Figure 45. Decommutation & Shipping Data Entry Program Flow Diagram

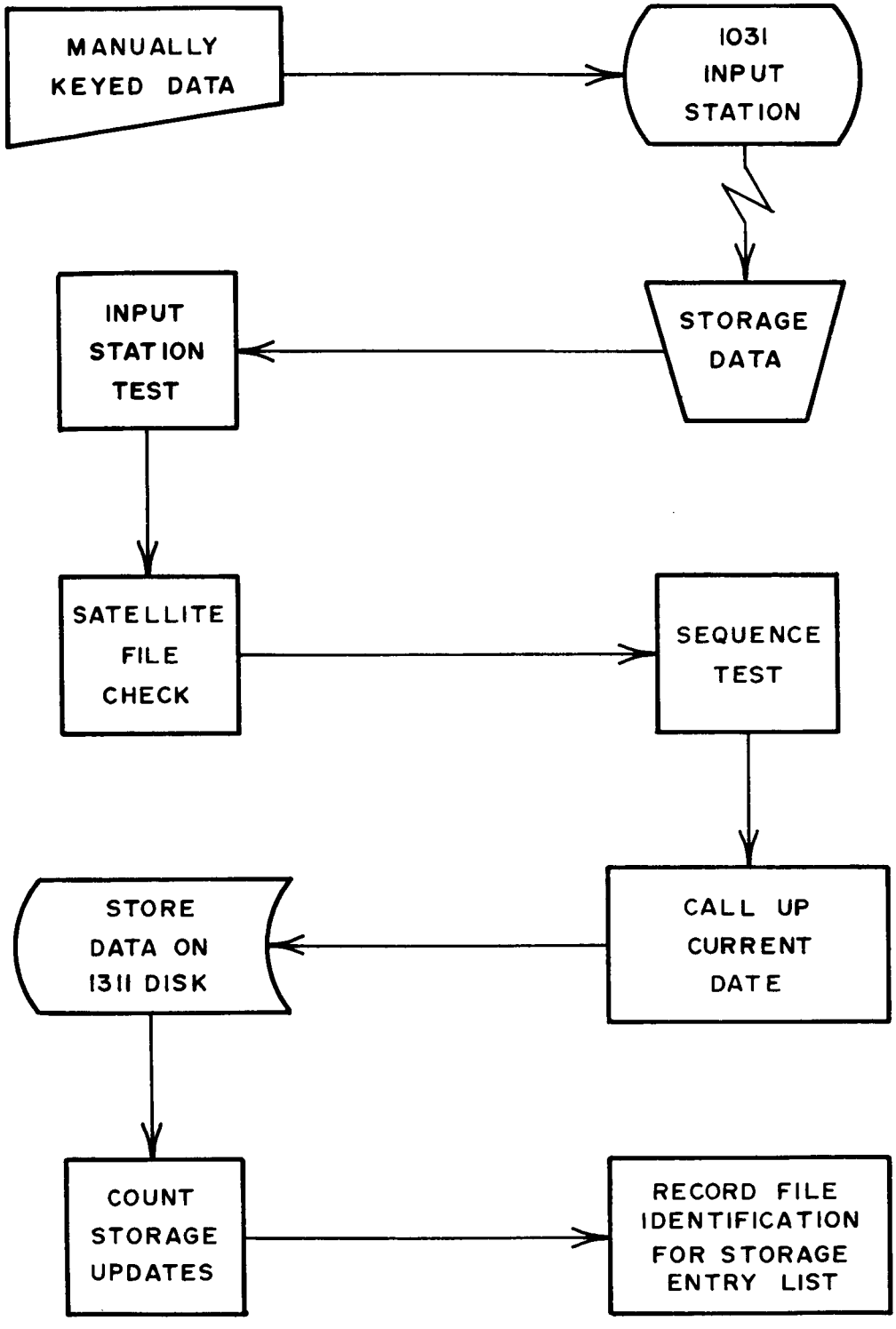

Figure 46. Storage Data Entry Program Flow Diagram

checks of files are made, and then the current date is called forth the CPU stores data, updates the entry and places the identification characters of the entry in the storage entry list.

PRODUCTION CONTROL MANAGEMENT

A generalized program is illustrated in Figure 47 to show how the Production Control Center communicates.

Any message to be sent to one of the production areas, whether it be for instructions or inquiries, are entered through a 1031 input station. The message can be manually keyed or entered on pre-punched cards. The message data will be sent to the 1401 central processor for interpretation and then an output sent to a 1033 output station selected according to the message content. The output will consist of production control verifications, messages to the analog data accounting office, instructions to computer monitors or instructions to the 1401 operations area.

This type of communication will be bi-lateral between the Production Control Center and both the analog accounting office and the 1401 operations area. Since Figure 47 is indicative of the concept of communication between them.

PRODUCTION CONTROL CENTER DIRECT MESSAGE CONTROL

The flow diagram (Figure 48) indicates the process used by the Production Control Center for internal message control. If the center needs production control accounting data or summary information it obtains it by sending a message to the system. Entry is either by manual keying or punch card into a 1031 input station. The message data are analyzed and responded to by the 1401 CPU which extracts the required data from disk storage. The output is sent to a 1033 output station which prints out either file data listings or summary data.

PRODUCTION CONTROL 1401 OPERATIONS COMMUNICATIONS AND PRODUCTION FLOW DIAGRAM

Efficient operation of the Production Control and Accounting System is contingent on well organized communication between the Production Control Center and the operations office of the 1401 CPU. All scheduled outputs for production control purposes, as well as unexpected outputs, will be directed by the Production Control Center.

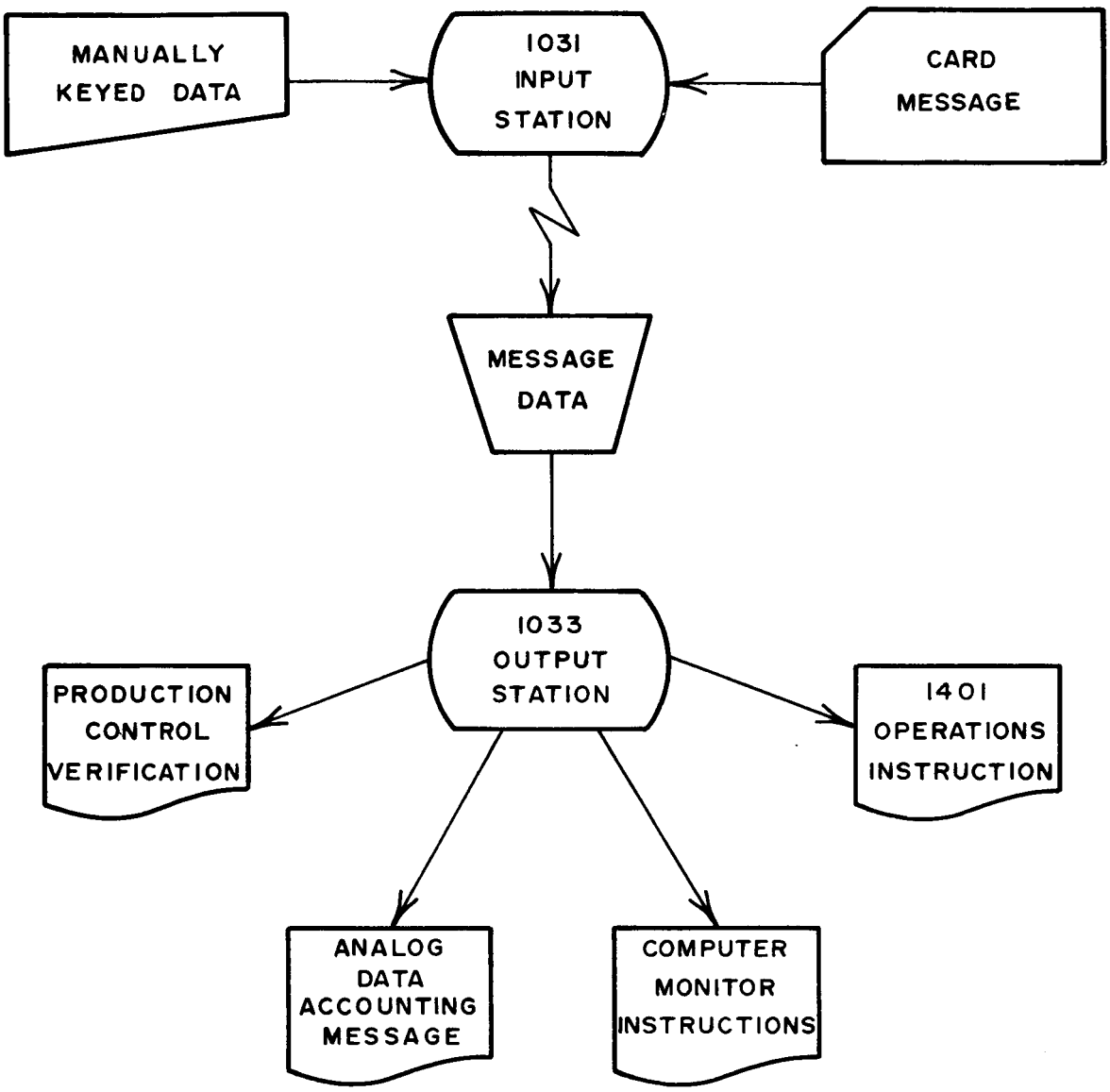

Figure 47. Production Control Center Management Control Program

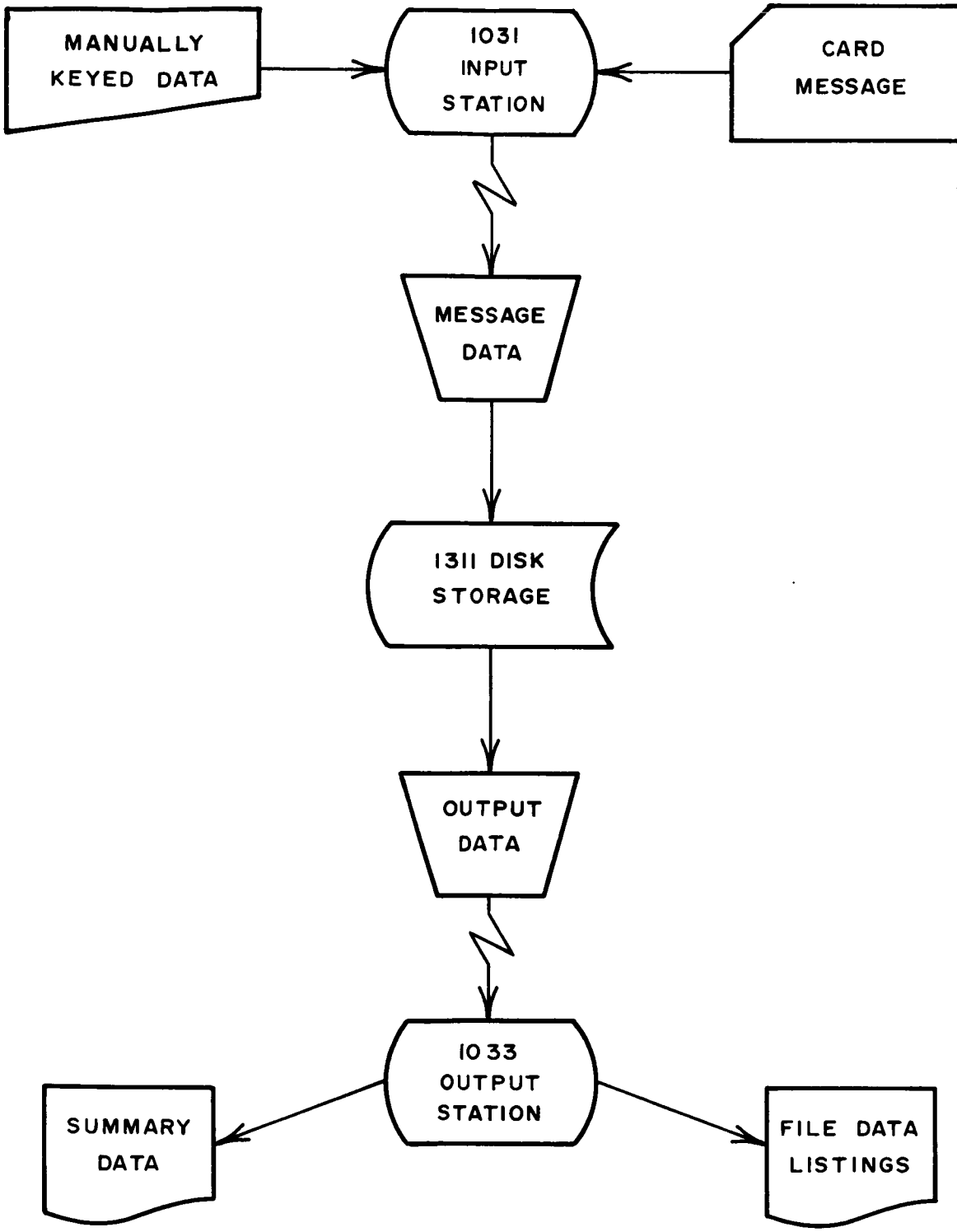

Figure 48. Production Control Center Direct Message Control Flow Diagram

The 1401 operations center will, in turn, perform required processing task and communicate with Production Control to inform it that work has been completed.

Figure 49 shows the communication process of both areas.

1. Production Control Center

When the Production Control Center wants processing work to be performed it will enter manually keyed instructions or punch cards with data processing instructions via a 1031 input station. These messages will normally be pre-established and will be codes to inform the CPU to reference more detailed instruction formats in disk storage. An example of this would be the assignment of a number or alphabetic character, which allows a program to enter an appropriate message table an extract a longer printout of explicit instructions. The processing instructions will be printed out at a 1033 output print station located in the 1401 operations area. It is preferable to use a 1033 output station for printing messages instead of the 1403 printer attached to the CPU in order to avoid printing conflicts.

2. IBM 1401 Operations

The 1401 central processor will accept punched card job stacks as program inputs or call routines from the executive program on magnetic tape. It will then reference the production control and accounting data stored on the 1311 disk storage and perform the required outputs. These outputs may be a weekly storage of the master file on magnetic tape, station to station listings, analog to digital chronological listings, listings of files for various processing functions and statistical summaries. The announcement of work performed by 1401 operations to the Production Control Center can be automatic and be done at the termination of a computer run or by use of a 1031 input station. In either case the 1401 operations message will be handled by the CPU and printed out on a 1033 output station located in the Production Control Center.

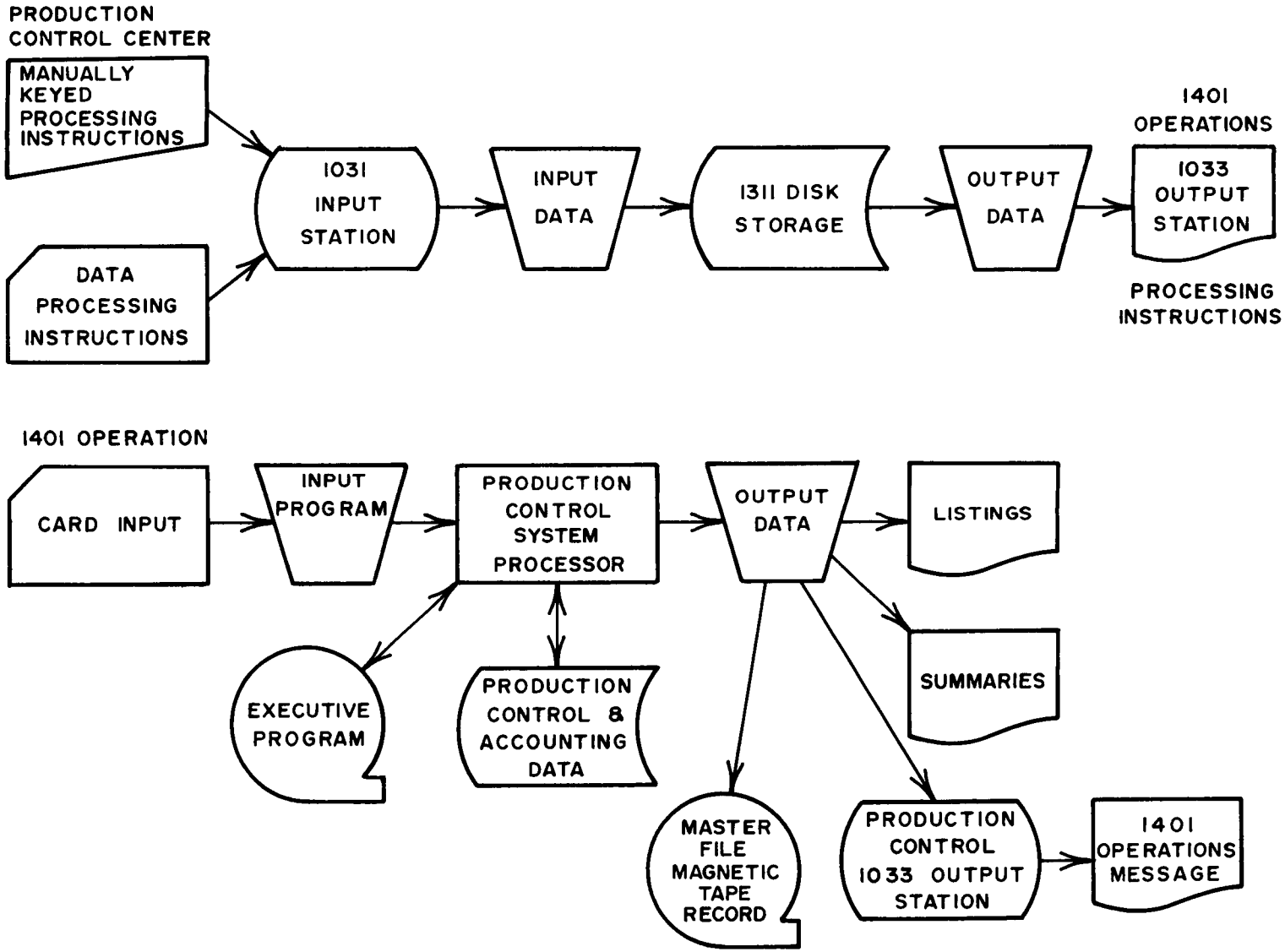

Figure 49. Production Control 1401 Operations Communications and Production Flow Diagram

CONCLUSIONS

This report has presented a study of the methods of production control and accounting information storage used by the Data Processing Branch at Goddard Space Flight Center. It has presented an alternate method of automating many of the functions of the present data handling system. Many of the repetitive tasks associated with punched cards have been eliminated and the accounting data has been consolidated for instant access.

The study has shown how an available, government owned computer, the IBM 1401 can be utilized effectively to meet the current system requirements and still have the capability for expansion. This results in two fold savings for NASA, in that it takes advantage of existing equipment, and that it relieves the Data Processing Branch from placing a workload on larger, much higher priced computer systems that should be used for direct support of GSFC's scientific missions.

The areas of timing have been explored to find out how the work load is translated from external physical requirements to machine performed activities. The manual loading times, although long in terms of a work day, have little effect upon the machine. The activities at the different terminals suggested for the system, are remote from one another, and present no discernible loading conflicts. Movement of the data from input to storage by the system is accomplished easily and rapidly, and the time consumed is small compared to the time the system is available for use during the normal period of activity.

Output functions place constraints upon the system only in circumstances that are in the extreme. The example given for a total storage output is illustrative of such a situation.

Anticipated queuing can be handled by proper scheduling techniques and interrupts on a priority basis will seldom be noticed by the people operating the system.

Finally, it is reiterated that this system has been developed to facilitate the current methods of production control and accounting operations. It does not attempt to redefine or add accounting variables to the system, rather it has stressed facility of placement of the presently used ones, and has pointed out that large scale rearrangements or increases of the variables can still be handled without taxing the system.

ACKNOWLEDGEMENTS

The author would like to acknowledge his appreciation to the many people who have been instrumental in helping him prepare this report. In particular he expresses thanks to Mr. Taro Terashi who has spend many hours in consultation and assistance in the development of the document, to Mr. Thomas H. Luter and Mr. Arthur C. Tonkinson for their contributions of a wealth of technical information involving the system, to Mr. Frank A. Greer for his assistance in defining the requirements for the operational aspects of the systems and to Mr. Marc J. Selig for his cooperation in establishing the working guidelines for the proposed system.

APPENDIX

SPECIFICATIONS FOR THE PRODUCTION CONTROL AND ACCOUNTING SYSTEM

Scope

This specification contains the requirements and the system configuration for a production control and data collection system to be located at Goddard Space Flight Center. The system will be used to replace the accounting methods used for supervisory control of production in the Data Processing Branch of the Information Processing Division.

Applicable Documents

IBM Systems Reference Library

IBM 1401 System Operation Reference Manual — File Number 1401/1460-01 Form A24-3067-1.

IBM 1030 Data Collection System — File Number T-P-09 Form A24-3018-2.

IBM Disk Storage Drive — File Number 1311-07 Form A26-5991-0.

IBM Transmission Control Unit — File Number T-P-09 Form A24-3244-1.

IBM Communications IOCS Specifications, IBM 1401 and Direct Data Channel — File Number 1026-30, Form C24-3241-2.

IBM 1401 Data Processing System Reference Manuals Edition A24-1403-5.

Requirements

General Requirements. The production control system will maintain an active account on record files kept on fifteen (15) satellites for an eight (8) week cycle. It is expected processing on any file of data will be completed during this period and the file will be retired to a completed records storage medium. There will be an average of one hundred and fifty (150) files (hereafter referred to as entries) per satellite per week. Each entry can consist of up to three hundred and twenty (320) binary coded decimal, seven bit characters with all

files of uniform length and structure. The total record keeping storage space will therefore require five million, seven hundred and sixty thousand (5,760,000) character storage locations. (15 satellites/week × 8 weeks × 150 files/satellite × 320 characters/file = 5,760,000 characters). There are four specific tasks the production control system will perform. They are as follows:

Functional Requirements.

The system will operate as a data collection facility for six (6) remote input stations. It must accept inserted information and store it in a large memory library. The information from the input stations will consist of the status of magnetic tapes being processed, and their location in the processing cycle. The data input from the remote stations will be random through two eight hour operational shifts. The number of inputs at any time will consist of one (1) to eighty (80) characters.

The system will output, upon request, the current status of any record of information. Each record will consist of 320 BCD characters. This output operation will be performed concurrent with the data collection activities of the system.

The system will maintain a summary of the data collection records which can be referenced on a daily basis. The summary will contain the total number of files that have been received, digitized, edited, decommed, culled, released, and the time of release. The summary will also contain the number of files backlogged for digitizing, editing, decommutation, shipping, and the total in processing. It will contain the number of files received and files culled since the previous summary report. Summary update will be concurrent with data collection activities.

To support the production control process, the system will be required to print out formatted listings of the data collected daily and weekly, and to also produce output listings of specified portions of the stored data, in part, or in whole.

Equipment Specifications

The system will consist of IBM equipment currently located at, and used by the Data Processing Branch, Information Processing Division of the Goddard Space Flight Center and the additional IBM equipment that can be immediately connected to the existing configuration.

Available Equipment.

IBM 1401 Processing Unit

Hi-Lo Equality Compare Feature No. 4575

Multiply-Divide Feature No. 5375

Print Storage Feature No. 5585

Column Binary Feature No. 1990

Advance Programming No. 1060

Sense Switches No. 7600

Seek Overlap No. 6400

Four (4) 729 Mod IV Magnetic Tape Drives

1402 Card Punch/Reader

1403 Printer

Equipment To Be Added.

1401 System Additional Equipment

One (1) Magnetic Core Storage Unit, 8K character memory 1406-2.

One (1) Disk Drive with Controls Model 1311-4

Two (2) Disk Drive Model 1311-2

Disk Adapter Feature No. 3339

Direct Seek Feature No. 3281

Scan Disk Feature No. 6396

See Overlap Feature No. 6400

Three (3) Disk Packs Model 1316-1

One (1) Auxiliary Console Model 1409-2

Console Adapter No. 2263

One (1) Transmission Control Unit Model 1026-1

Line Adapter Feature No. 4790

Expanded Line Feature No. 3837

Interrupt Feature RPQ

1030 System Equipment

One (1) Input Station with Controls Model 1031-A2

Six (6) Input Stations Model 1031-B2

Four (4) Output Printers Model 1033-1

One (1) 1033 Printer Attachment Feature Number 1279.

BIBLIOGRAPHY

1. Goddard Space Flight Center, The Data Processing Branch, X-545-64-242, August 1964.

2. Goddard Space Flight Center, Telemetry Data Processing Source Book, X-545-65-198, Greenbelt, Maryland, May 1965.

3. Narrow, Bernard, Goddard Space Flight Center, Satellite Telemetry Data Processing at Goddard Space Flight Center, X-564-66-336, Greenbelt, Maryland, July, 1966.

4. Goddard Space Flight Center, Telemetry Data Processing, X-564-65-384, Greenbelt, Maryland, September, 1965.

5. Data Processing Branch, Goddard Space Flight Center, Atmosphere Explorer-B Telemetry Data Processing Plan, X-564-66-297, Greenbelt, Maryland, July, 1966.

6. Mahoney, Michael and Quann, John J., Goddard Space Flight Center, Telemetry Data Processing Plan For The OGO-A Mission, X-545-65-350, Greenbelt, Maryland, September, 1964.

7. International Business Machines Corporation, Reference Manual IBM 1401 Data Processing System, A24-1403-5, White Plains, New York, 1962.

8. International Business Machines Corporation, IBM Systems Reference Library, System Operation Reference Manual, IBM 1401 Data Processing Systems, A24-3067-1, White Plains, New York, 1963.

9. International Business Machines Corporation, IBM Systems Reference Library, IBM 1311 Disk Storage Drive, A26-5991-0, White Plains, New York.

10. International Business Machine Corporation, IBM Systems Reference Library, IBM 1030 Data Collection System, A24-3018-2, White Plains, New York, 1963.

11. International Business Machine Corporation, IBM Systems Reference Library, 1026 Transmission Control Unit, A24-3244-1, White Plains, New York.

12. International Business Machines Corporation, IBM Systems Reference Library, Communications IOCS Specifications, IBM 1401, 1440 and 1460 with IBM 1026 and Direct Data Channel, C24-3241-2, White Plains, New York, 1964.

GLOSSARY

Accounting Data — Information on recorded data, and on the processing functions performed to reproduce it in various stages to intelligible form.

Aerospace Telemetry — The method of transmission of information from distant origins to accessible locations of a physical variable that can be numerically scaled.

Analog Data — A representation of magnitude.

Analog Magnetic Tape — A magnetic tape with recorded analog voltage signals of data acquired from satellites.

Analog to Digital Conversion — That process whereby variable analog signal quantities are changed to a corresponding digital quantity in numerical form.

BCD — Binary Coded Decimal

Buffer Tape — A magnetic tape containing initially converted analog to digital data.

CPU — Central Processing Unit. A stored program, arithmetic, digital logic computer capable of accepting, performing manipulations and outputting digital data.

Computer Run — A programmed task, or sequence of tasks, performed on a computer

Data Processing Branch — The official GSFC organization responsible for the processing and accounting performed on satellite data.

Decommutation — The separation of individual experimenter data from a digital tape containing sets of experiments.

Digital Data — Information based on a discrete interval which can be manipulated by arithmetic methods.

Digital Magnetic Tape — A magnetic tape with recorded digital voltage levels.

Entry — The insertion of file data into the system.

Edit — The process of checking, converting and reconstructing data formats.

File — A specified length of characters containing processing data on satellite orbits.

Master File — All the pertinent accounting information collected and retained on all satellites in the system for a specified storage period.

Pass — An orbit of a satellite around the earth.

Record — A file of information recorded on magnetic tape or on disk storage.

Telemetry Data — Data transmitted in a constructed signal arrangement from a satellite.